olutely dead things but do contain a potency of life in them to be oul was whose progeny they are, nay they do preserve as in a icacy and extraction of that living intellect that bred them.

—*John Milton*

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Contents

NOTE

The reader is referred to the Preface for an explanation of the system of starring fractures.

I

The Different Kinds of Fractures

It is important to recognise the direction of the force causing a fracture since this affects the method of reduction, the speed of repair the liability to mal union, and the extent of the damage to the soft parts. The nature of the force and its direction can often be guessed from the history of the accident, and they can nearly always be deduced from the radiographs.

There are five main forces: direct blow angulation, rotation, vertical com pression, and forced flexion of a joint.

Direct blow

A bone struck at an angle to its surface breaks in different ways depending on the nature of the force. Three types of fracture are recognised. tapping crush, and penetrating

Tapping fracture This occurs when a force of dying momentum is applied over a linear area. It is seen typically when a footballer is hacked on the shin (fig 1) The bone breaks at the point of contact and absorbs the entire force. The line of fracture is transverse. In the leg and the forearm—the commonest sites—the second bone often remains intact, and when it does there is little or no displacement. The skin may be split at the site of impact; apart from this damage to the soft parts is negligible because the bone absorbs the force of the blow

Crush fracture This occurs when the force is applied over a large area. The momentum is greater and the force besides breaking the bone also crushes the soft tissues. Treatment of the soft tissues often postpones definitive treatment of the bone. The bone breaks transversely and may be comminuted, i.e. in many fragments (fig 219) In the leg and forearm the second bone breaks transversely nearly at the same level.

Penetrating fracture This occurs when a great force is applied over a small area, as in a gunshot wound. The bone is splintered in a characteristic manner (fig 3). The damage to the soft parts may be trivial or serious. Although tissues in the line of flight are often pushed aside and escape damage a main artery or a main nerve may be severed. A large fragment of shell acts as a crushing force and not as a penetrating force.

Angulation

The bone breaks at the point of greatest stress and not where the force is applied. The line of fracture is transverse and there is usually a small wedge shaped third fragment (fig 2) The soft tissues at the site of the fracture escape damage except that a bone-end may puncture the skin

Rotation

The limb is twisted and the bone breaks at the weakest point. The line of fracture is spiral and involves a wide extent of the shaft (fig 4) In the leg the two bones break at different levels (fig 213). Damage to the soft parts is slight.

Vertical compression

The force passes up the bone and the soft parts are not damaged Either the bone splits along its length in several planes (fig 5): displacement is then unexpectedly small and repair unexpectedly rapid. Or there is a transverse fracture through the lower part of the shaft and a vertical split into the joint (fig 97a) The damage to the joint is serious and often permanent.

Forced flexion of a joint

At the knee and elbow a special kind of fracture occurs when the joint is forcibly bent while the extensor muscles are in strong contraction. At the elbow the olecranon and at the knee the patella break transversely and at the same time the extensor muscles tear When the muscle tear is complete the bone fragments separate widely

PATHOLOGICAL FRACTURES

A force of some magnitude must be applied before a bone breaks, and when the force is insufficient to break a healthy bone the fracture is said to be pathological or spontaneous.

Pathological fractures occur: (*a*) With general diseases such as tabes, owing perhaps to uncoordinated muscle action from the loss of muscle sense (fig 6) (*b*) When the bones throughout the body are fragile, as in fragilitas ossium (fig 7) osteitis deformans (fig 8) and senile osteoporosis (fig 9) And (*c*) when the bone is weakened locally by a cyst or a neoplasm (fig 10).

Pathological fractures are treated, secundum artem as ordinary fractures. Union can be expected except in tabes and sarcoma.

Sometimes a bone normal in every way breaks during ordinary use. This kind of pathological fracture is called a fatigue fracture. The patient (without having met with any injury) suddenly feels pain in a bone. The radiograph shows a linear crack without displacement. Often the radiograph at first shows nothing; only the later appearance of callus proves that the bone had broken (fig 11).

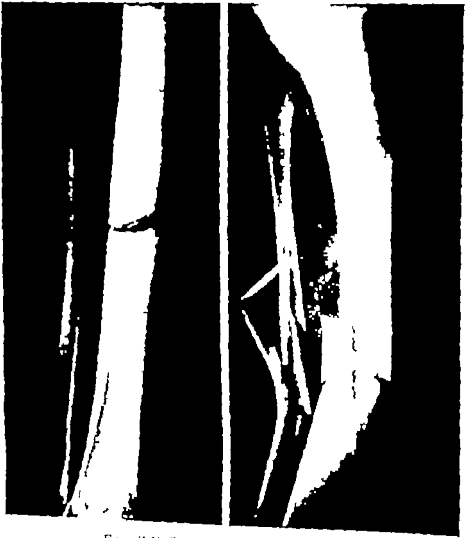


Fig 1 (*left*) Fracture caused by a tipping force.
Fig 2 (*right*) Fracture caused by an angulating force.
Note the separate triangular fragment of the tibia.

Fig. 3. Fracture caused by a penetrating force. Gunshot wound.

Fig. 4. Fracture caused by a twisting force. Intervals, five weeks, and three months.

Fig 5 Fractures caused by a vertical force *Left*, fracture of the os calcis; *right*, vertical fracture of the tibia.

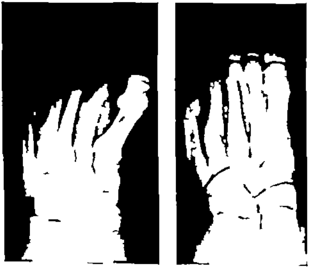


Fig 6 Pathological fractures due to syphilis. Two are healing the fracture of the fifth metatarsal is recent.

Fig 7 Pathological fracture due to fragilitas ossium.

Fig 8. Pathological fracture due to Paget's disease. The fracture is not complete.

Fig 9. Pathological fracture due to osteoporosis

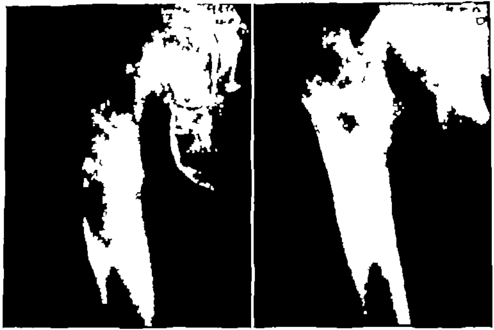


Fig 10 Pathological fracture due to carcinomatosis *Left* before the fracture *right* three months after the fracture.

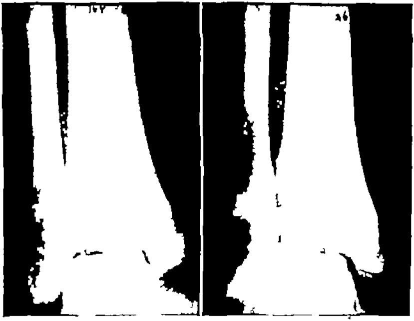


Fig 11 Pathological fracture due to fatigue. Interval. two and a half months.

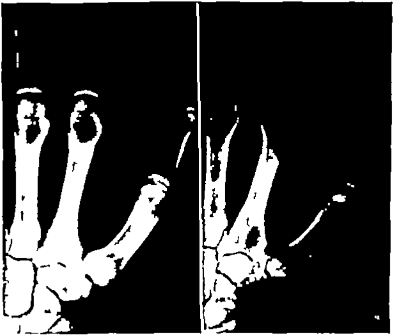


Fig 12. Fracture invisible in the first radiograph. Interval: thirteen days.

2

The Diagnosis of a Fracture

SYMPTOMS

There is a history of an injury succeeded immediately by pain The pain varies in intensity it may be agonising or in the case of an impacted fracture little more than a nuisance. Intermittent spasms of pain suggest a fracture. The patient often feels momentary nausea at the time of the accident

SIGNS

Swelling is not pathognomonic of a fracture; it may be due simply to a bruise. On occasions signs are many When the fragments are displaced the contour of the part may be visibly abnormal. Irregularity of the surface of a subcutaneous bone like the clavicle may be palpated The patient usually refuses to move the damaged limb and passive movement is resisted. Abnormal mobility and crepitus (the noise made by one bone rubbing against another) may be felt in the course of the examination but no attempt should be made to elicit them. In the lower limb there may be an apparent difference in the length of the two legs. However *only two signs are reliable* namely local tenderness over the site of the break, and a fracture line visible in a radiograph.

It is helpful to get the patient to localise the injury if he is asked to put one finger on the most painful spot he usually pinpoints the site of the fracture Do not palpate too much. Once a fracture has been suspected it is a kindness to the patient to desist from further examination until a radiograph has been seen.

X rays

It is wise always to assume the presence of a fracture until it has been excluded by radiography

X rays must be taken in more than one plane. Sometimes even in two planes at right angles to one another a fracture may be invisible and its presence only disclosed by later radiographs (fig 12)

Radiography is valuable for excluding a fracture. For medico-legal reasons the doctor should insist on an X ray examination in any suspected case of fracture, even though the presence or absence of a fracture makes no difference to treatment; and the onus of refusing should be on the patient.

When a fracture is present an intelligent and accurate description enables

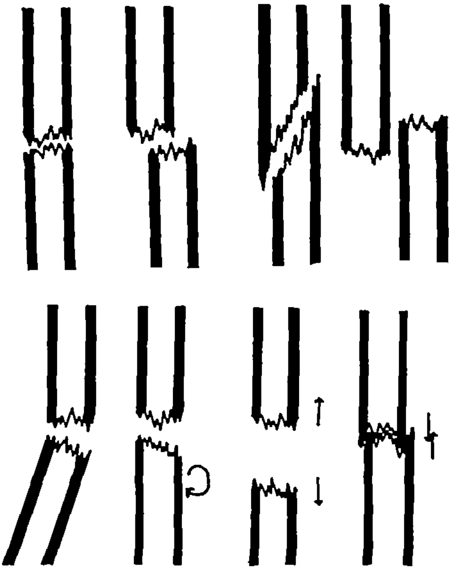


Fig. 3. Kinds of displacement. *Top, from left to right*: no displacement, shift, slight shift and slight overlap, marked shift and overlap. *Bottom, from left to right*: angulation, rotation, distraction, and impaction.

the correct form of treatment to be deduced The following particulars should be noted

Position of the fracture Is the fracture in the shaft, or in the metaphysis? And does it involve an articular surface? A fracture through cancellous bone always unites, a fracture of the shaft may not.

Direction of the fracture line Is it transverse (fig 1) oblique (fig 208) spiral (fig 2), or longitudinal (fig 5)?

The number of fragments There may be three in a fracture caused by angulation (fig 3) or many in a fracture caused by a crush (fig 222) or a gun bullet. Where there are many fragments the bone is said to be comminuted.

The degree of completeness of the fracture The bone ends may be separated by a gap When the fragments are not separated the fracture is seen only as a hair-line (fig 129) A wide area of rarefaction without displacement is more likely to be a vascular channel than a fracture. A hand lens often reveals a fracture not seen by the naked eye. Occasionally a fracture is said to be impacted, i e. although the fracture is complete the fragments are interlocked (fig 175) Sometimes there is not any loss of continuity the fracture is then said to be incomplete (fig 108) A special form of incomplete fracture is seen in children when only the cortex of the bone buckles, leaving the shaft entire (fig 114).

The displacement There may be shift, overlap angulation rotation or distraction (fig 13). These displacements are considered in detail on page 23

Fresh X rays should be taken after the reduction of a fracture and after any change of plaster If they are not taken and reduction is unsatisfactory or mal union develops the doctor will be blamed and rightly so

DAMAGE TO SOFT PARTS

This should always be assessed. In particular we want to know four things. Has the skin been breached and, if breached, has any skin been devitalised? Have the soft tissues been crushed? Has a main nerve been damaged? Is the circulation to the limb distal to the fracture satisfactory?

3

The Principles of the Treatment of a Fracture

Many fractures join satisfactorily without any treatment. Treatment is only required to prevent non-union, malunion and stiffness.

NON UNION

The term non union needs defining It does not mean what it says In non-union there is not an absence of union. Non-union implies that the material joining the broken ends is fibrous tissue and not bone. When there is not any tissue between the broken ends we speak of pseudarthrosis. Pseudarthrosis is rare, non-union is not uncommon. It would be better to replace the term non-union by fibrous union for that is what is meant; but the term non union is long established and will not easily be ousted.

Apart from endothelium and epithelium which have their own methods of repair every structure in the body when divided unites by fibrous tissue, except bone. Why is it that bone is the only tissue in the body that joins by bone? We believe that all repair tissue at its inception is the same, and that what happens to it subsequently depends on the stresses to which it is subjected. If the young repair material is stretched it ends up as a pliable scar if it is compressed it ends up as rigid bone. One should therefore, during the mending of a fracture, encourage everything that compresses the embryonic callus and discourage anything that stretches it.

FACTORS FAVOURING COMPRESSION

Compression can be brought about by muscle tone, by voluntary muscle action, and by weight-bearing

Muscle tone

Whenever there are muscles attached to the two fragments they exert compression by their tonic activity Muscles are at work even when the body is supposedly at rest, and this mild continuous invisible activity is called muscle tone. That the ends of a broken bone tend to overlap is evidence that muscles are all the time forcing the bone ends towards one another even when they are not in voluntary action.

Voluntary muscle action

The compression exerted by muscle tone can be augmented by voluntary muscle activity During activity at least two sets of muscles are at work. At the elbow for instance, while the flexors are actively shortening the extensors are actively lengthening: one group of muscles is hauling in and the other group is paying out, and both are taut. The combined action of the two groups of muscles is to compress the fracture site.

Weight-bearing

Weight-bearing is an obvious method of exerting compression and patients with fractures of the lower limb should be got on to their feet as soon as possible.

FACTORS ADVERSE TO COMPRESSION

Stretching is the opposite to compression. The repair material between the ends of a broken bone can be stretched by traction by hinging and by rotation.

Traction

As a rule muscles tend to approximate broken fragments but in the case of the olecranon and the patella they do the reverse. When muscles pull the fragments apart their pull must be neutralised by internal fixation of the fragments

The ends of a broken bone may be kept apart by excessive traction. In the treatment of many fractures skeletal traction is used to reduce overlap and there is always a danger that the traction will more than balance the compression exerted by the muscles. In which case the repair material between the broken ends will turn into fibrous tissue instead of into bone.

Hinging

When a fracture angulates, the site of the fracture is compressed on one side and stretched on the other According to our hypothesis bone should be formed on the side compressed and fibrous tissue on the side not compressed. This is precisely what happens. In any fracture that has joined with an angular deformity the radiographs show all the callus to be on the inside of the bend (fig 14) If a fracture is repeatedly hinged, first in one direction and then in another distraction will predominate and the end result will be non-union, i e. union by fibrous tissue. Indiscriminate continual hinging therefore must not be allowed Luckily when there are muscles attached to both fragments the muscles themselves by their tonic activity prevent hinging When there are not muscles attached to both fragments there is nothing to prevent the bone ends from hinging continually and in all directions.

Tonic activity of muscles will only prevent hinging so long as the fracture site is not being disturbed by external forces. Tonic activity of muscle is not powerful enough to prevent hinging when the fragments are acted upon by

Fig 14. All the callus is laid down on the inside of the bend, as a result of compression.

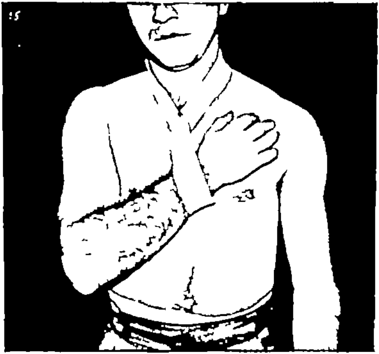


Fig 15 Collar-and-cuff splint

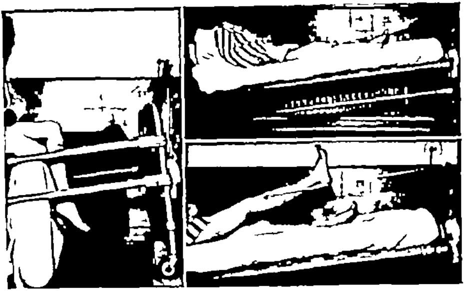


Fig 16. Skeletal traction. Pin through the upper third of tibia; end of bed raised ten inches; ten pound pull *Top right* leg lying on a pillow on the bed. *Bottom right* patient lifting his leg *Left* patient bending his knee after the lower half of the mattress has been let down.

outside forces. This is why for example, when treating a fracture of the shaft of the humerus the physiotherapist encourages the patient to flex and extend the elbow but does not allow him to abduct his shoulder In the abducted position gravity would cause hinging at the site of the fracture.

Rotation

If bone ends are allowed to rotate on one another the young repair material is stretched and the stretching induces fibrous union. Rotation at the site of a fracture therefore must not be allowed. In general, muscles when in action prevent rotation but in the forearm there are muscles whose function is to make the radius and the hand as a unit rotate round the ulna, and when they contract the young repair material is stretched.

PREVENTION OF ROTATION AND HINGING BY PURE SPLINTAGE

Hinging and rotation must be prevented in certain fractures if union by bone is to be achieved This is done by splintage. But the splintage has to be of a special kind. It has four attributes. It must be continued throughout the whole time the bone is mending it must not be interrupted, it must be rigid and it must contain two angles to prevent rotation. The initials of these four attributes compose the word PURE: P for prolonged, U for uninterrupted, R for rigid, and E for extensive, meaning by extensive that the splint must be extended up and down until it incorporates two angles one above and one below the fracture.

ments until the fracture has consolidated. A physiotherapist should not be encouraged to move joints. Her task is to make the patient move his own joints, not to move them herself

SHRINKAGE OF THE CAPSULE

One of the penalties of old age is an increasing stiffness of the joints. It would seem that joint capsules have a natural inclination to shrink and are only kept at full length by being repeatedly stretched. When a joint is splinted the stretching effect of movement is withdrawn and some stiffness is inevitable from shrinkage of the capsule. From this two conclusions can be drawn. First, that no more joints should be immobilised than can be helped, and second, that when a joint has to be splinted it should be held in the position that stretches equally all parts of the capsule. This is not so important in a joint like the elbow where only the middle arc of movement is ordinarily used. But it is supremely important in the hand where any restriction of movement is disabling

INEXTENSIBILITY OF MUSCLE

Muscles have two actions; they shorten and they lengthen. And whenever either function is in abeyance for a while it is lost. From a study of infantile paralysis it is known that when a muscle is held in its lengthened state for a while it loses its ability to shorten. It is not so well known that a muscle held in a shortened state for a while loses its ability to lengthen. Loss of the ability to lengthen accounts for most of the stiffness that develops during the mending of a fracture.

There should not be any difficulty in retaining extensibility in muscles that can be stretched to their full, but how are we to take care of muscles that are prevented from being stretched by being under plaster? Luckily it is not necessary to stretch a muscle to its full in order to preserve its extensibility: it is sufficient to interrupt occasionally the tonic activity of the muscle by active contraction of its antagonist. When one group of muscles contracts voluntarily its opposite group automatically relaxes. When, for example, a person wills himself to bend his knee his quadriceps relaxes. A stiff knee seldom follows a fracture of the shaft of the tibia but it is common after a fracture of the shaft of the femur. This is because the man with a fractured tibia activates his knee muscles whenever he lifts his leg, which he does frequently and without thinking. The man with a fracture of the shaft of the femur neither lifts his leg nor bends his knee unless he is made to do so. That the loss of movement after a fracture of the shaft of the femur is due mostly to loss of muscle extensibility and only slightly to shrinkage of the capsule is shown by the fact that movement can be restored by lengthening the quadriceps at an operation.

Accordingly not only should a patient move unsplinted joints, he should try to move the joints that are under a splint. The splint will not permit a joint to move more than a few degrees but the muscles will automatically relax when their opponents are willed to contract.

INCONGRUITY OF JOINT SURFACES

Opposing articular surfaces are made to fit one another exactly And when a fracture involves a joint and the fragments are displaced—however slightly—the broken articular surface when mended no longer fits its opposite articular surface unless reduction has been meticulous. Exact anatomical reposition can rarely be obtained by a closed manipulation and often proves impossible at open operation. However if the damaged joint is allowed and encouraged to move, movement moulds the fractured articular surface so that it comes to fit its opposite number and in this way congruity is restored Therefore, in a fracture that involves an articular surface the joint should not be held still if it can be avoided. It is often possible to use a SIMPLE splint to maintain reduction and yet to allow movement of the damaged joint (fig 16).

ORGANISATION OF TRAUMATIC EXUDATES

When a bone breaks, blood leaves the vessels and seeps into the tissues, where it is organised and converted into fibrous tissue. The fibrous tissue later contracts down into a scar and the scar binds together everything in the neighbourhood. This is a serious contribution to post traumatic stiffness when the force that breaks the bone is also exerted on the soft parts. A compression fracture of the spine is a common injury It is caused by forced flexion of the back, and as or before the vertebral body breaks the extensor muscles of the back tear Widespread scarring within the muscles is inevitable. If the patient is got up immediately and made to touch his toes within ten days, the scar is kept on the stretch while it is forming, and the patient is saved from a residual annoying backache.

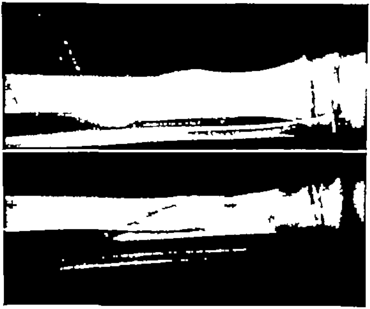


Fig 17 Fluffy callus (*left*) Laminated callus (*right*) Interval three weeks.

Fig 18. Remodelling of the bone after a fracture. Interval three years.

4

The Stages of Repair

It is not enough to treat only the bone: the soft structures are equally important, and they also require treatment. The object of treating the bone is to get bony union in good position. The object of treating the soft parts is to leave the limb as supple as before the accident. The soft parts may be injured at the same time as the bone is broken, but as a rule the damage to the soft parts is caused by splintage and by disuse of the limb.

The treatment of a fracture therefore consists of two separate parts:

1 Treatment of the BONE.

2 Treatment of the SOFT PARTS, and the PRESERVATION of the FUNCTION of the limb.

The two treatments are to some extent antagonistic, the bone requiring immobility and the soft parts movement. Usually treatment of the bone takes precedence over the treatment of the soft parts but as far as possible both treatments should be simultaneous. It sometimes happens that the bone does not require any treatment and then all treatment can be devoted to the soft parts.

The repair of bone can usefully be divided into four stages.

Stage I FORMATION OF ENSHEATHING CALLUS

The space between the ends of the bone is filled with blood and plasma. This fluid is prevented from leaking away into the surrounding tissues by stripped up periosteum and by muscle sheaths. The fluid clots, and the clot is organised. The organised material, of the consistency of setting glue, is called ensheathing callus.

Clinically when the fracture is complete, the ends of the bones move freely on one another.

The radiograph shows either a gap or a linear crack.

Stage II. FORMATION OF CALCIFIED CALLUS

The pH of the fluid between the fragments is at first the same as that of blood. After a few days the alkalinity decreases on account of the release of CO_2 from the dead cells and of lactic acid from the muscles. The relative acidity causes absorption of bone from the bone ends. On account of this absorption the fracture line, which immediately after the accident may have been almost in

visible, becomes clearly defined at the end of ten days (fig 129). Later alkalinity becomes greater than normal and calcium is deposited in the ensheathing callus. Thereupon the callus becomes rigid.

Clinically at the end of this stage there is *union*. The two ends move as one, but angulate if subjected to stress.

In the radiograph a fluffy shadow surrounds the broken ends (fig 17).

Although there is *union*, real repair or *consolidation* has hardly begun. The two broken ends are now prevented from moving on one another so that repair proper i e. the fusion of the two raw bony surfaces with bone, can begin. Throughout this book the terms union and consolidation are given arbitrarily distinctive meanings. UNION *implies temporary firm linkage of the ends of the bone by calcified callus* CONSOLIDATION *implies permanent fusion of the ends with bone*

Stage III. FORMATION OF PERMANENT CALLUS

Osteoblasts from the centre of the bone and from the periosteum invade the calcified callus, absorb it and replace it by bone.

Clinically at the end of this stage there is consolidation. The two ends not only move as one, they are now able to resist stress without angulating or refracturing

In the radiographs the gap between the ends is filled with bone, and the callus outside the bone is laminated and fusiform in shape (fig 17).

Stage IV REMODELLING OF THE BONE

Unwanted callus disappears. This change can be traced in successive radiographs. Bone trabeculae at the site of the fracture are gradually absorbed and relaid to meet the new stresses they have to bear in accordance with Wolff's law This is a silent change. It is astonishing how effectively the body accomplishes this transformation (figs. 18 110).

5

Treatment of the Bone

Treatment varies in the different stages.

Stage I. REDUCTION
II SPLINTAGE until UNION
III. PROTECTION until CONSOLIDATION
IV Nil

STAGE I REDUCTION

DEFINITION

By reduction is meant placing the bone ends in contact with one another and in good position.

In contact

Bones will not join unless they are in contact. Usually the fractured ends automatically come into contact because the muscles pull them towards one another Exceptions occur (1) When the muscles are pulling in opposite directions (fracture of the patella). (2) When one bone end pierces the surrounding muscle (longitudinal fracture of the shaft of the femur). (3) When, in the leg or forearm, the fractured ends of one bone are held apart by an intact fellow bone. And (4) when the bones are pulled apart during treatment by excessive traction.

In good position

If the bone ends are replaced so exactly that the original contour of the bone is reformed reduction is perfect. Strictly in all cases in which exact anatomical reposition has not been achieved there is malunion. If however the deviation from normal is not enough to interfere with function we say that reduction is good. With a fracture of the shaft good reduction is sufficient; when a fracture involves an articular surface perfect reduction is desirable.

TYPES OF DISPLACEMENT

Since the methods of reduction depend on the type of displacement one must learn to recognise the different displacements from the radiographs. There may be shift, overlap angulation, rotation, and separation; or any combination of these (fig. 13 page 10).

Shift

This may be in any plane. Shift is not of much importance in a fracture of the shaft. This is fortunate since it is a difficult displacement to correct.

Overlap

This is usually combined with shift. Overlap results in shortening. Moderate shortening of half an inch or so is immaterial to good function except in the forearm. Here it is of importance since a shortened radius cannot rotate around an ulna of unimpaired length. Overlap of one bone of the forearm limits rotation, equal overlap of both bones may not cause any loss of rotation. In a spiral fracture slight overlap has the advantage of ensuring that one bone-end is impinging on the other and is an insurance against non union.

Angulation

This may be in any plane. Sometimes it interferes with function, sometimes not.

When the joint nearest the fracture is a hinge joint, angulation causes disability because the centre of gravity ceases to pass through the middle of the joint, and great strain is put on the muscles and when they tire on the ligaments; for example, an outward bow in the upper third of the tibia puts strain on the knee, and an inward bow in the lower third of the tibia puts strain on the ankle. *Angulation in these two cases should be corrected.*

Angulation parallel to the plane of movement alters the arc of movement. This does not cause disability if only the middle of the range is ordinarily used. A backward angulation in the lower half of the tibia, for example, is not of much importance because extreme dorsiflexion and plantarflexion of the ankle is seldom wanted.

Similarly angulation near a ball and-socket joint is only important if the extreme of movement is in daily use. For this reason an angulation near the shoulder does not matter whereas an angulation near the hip joint does.

Rotation

This is serious in a bone situated between two hinge joints; for example, in a fracture of the tibia and fibula internal rotation of the lower fragment causes the knee and ankle to work in different planes. When the joint above the fracture is a ball and-socket joint the deformity can be compensated for by rotation at that joint and disability is slight e.g in a supracondylar fracture of the humerus.

Separation

If the bone ends are pulled apart either by excessive traction or by muscle pull they unite by fibrous tissue and not by bone.

In a fracture of the shaft the muscles bridging the fracture are strong enough to overcome the harmful effects of traction. But if the patient does not

activate his muscles traction is potentially harmful. *When traction is being used it is most important to make the patient use his muscles*

In fractures of the olecranon and the patella the muscles pull the bone ends apart, and the pull must be neutralised by internal fixation of the fragments.

WHEN REDUCTION IS NOT REQUIRED

The layman believes that every fracture needs to be set, and that if not set it will not join. He is mistaken. There are, indeed, four occasions when it is proper not to attempt to reduce a fracture: (1) When there is not any displacement, as in a fissure fracture of the skull. (2) When the displacement does not matter. A displacement, however gross, may be ignored provided that it will not prevent the patient from regaining full function. Only experience tells us whether the position is good enough. (3) When reduction, though desirable, is not feasible, as in a comminuted fracture of the head and neck of the humerus. And (4) when reduction cannot be maintained, as in a fracture of a vertebral body. Under any of these circumstances reduction is superfluous.

TIME FOR REDUCTION

Reduction should be attempted as soon as possible, before the ensheathing callus begins to fix the fragments and before the muscles set from the clotting of the haematoma. Every hour counts; do not wait for swelling to subside. Delay only until the patient is comfortable in bed and until an X ray has been taken. Reducing a fracture is often the best method of treating shock.

METHODS OF REDUCTION

Closed manipulation. Setting a fracture is inexact and rarely achieves anatomical reposition, but it is the least dangerous and the simplest method of reducing a fracture. Before reduction is attempted the patient should be anaesthetised. This is done to render reduction painless and also to render it easier by abolishing muscle spasm. It helps the doctor as much as it helps the patient.

The doctor should have a clear understanding of what he is trying to reduce. The manipulation may have to be done in several stages, to correct first one and then another displacement.

Of the various displacements, *angulation* and *rotation* are easy to reduce. Shift cannot be corrected unless overlap is first overcome and even then may be difficult. For correcting *overlap* two methods are available: longitudinal pull and hinging. So long as it is being applied traction will pull a bone out to length, but overlap is nearly always combined with shift and unless while traction is being applied, the shift is corrected so that the ends impact, the bones overlap again as soon as the pull is released. In the hinging method the two fragments are angulated so that they lie almost parallel to one another. The ends are correctly rotated and brought into apposition in perfect position. The method is more easily carried out at an open operation.

Open reduction. This is the most exact method, but there is always a risk of sepsis, and operation should never be done except under ideal conditions.

Open operation is sometimes essential. (1) When one fragment is uncontrollable from without, e.g. in a lateral condyle of the humerus in a child. (2) When one fragment is entangled in soft tissues, e.g. in a longitudinal fracture of the shaft of the femur. (3) When the fragments are pulled apart by muscles, e.g. in a fracture of the patella. And (4) as a prelude to internal fixation.

Though not essential, open reduction is advantageous in transverse fractures with overlap especially in the forearm with an intact fellow bone. After exposure the bone ends are got end-on by means of a bone lever used as a shoe-horn.

STAGE II SPLINTAGE UNTIL UNION

Splints are used for two separate and distinct purposes: (1) to keep the bone ends still, and (2) to maintain a reduction. Each purpose is served by its own special kind of splint. To keep the bone ends still, PURE splintage is used, to maintain a reduction, SIMPLE splintage is used. Pure and Simple splints have already been defined on pages 15 and 16.

The doctor must decide whether any splintage is required and if so which kind. He should ask himself first whether PURE splintage is needed: if it is not, whether SIMPLE splintage is needed. Often there is no need of either.

PURE splintage is needed to prevent the bone ends from moving on one another when the muscles are unable to hold them still. Only three common fractures demand PURE splintage: transcervical fracture of the neck of the femur, fracture of the carpal scaphoid and a fracture of the shaft of the radius.

The only external splint that qualifies as a PURE splint is a plaster cast containing two angles. The immobility imposed by an external PURE splint conduces to stiffness and when PURE splintage is required it is often better to use internal fixation.

SIMPLE splintage is used to maintain a reduction. Therefore, when for any reason a fracture is not set there is not any point in applying a SIMPLE splint. Sometimes a PURE splint is required when a SIMPLE splint is not, e.g. for a fracture of the scaphoid.

SIMPLE splintage takes many forms. It may suffice to hold the neighbouring joint in a particular position. The plaster slab on the back of the forearm and hand used to maintain reduction of a Colles's fracture is a good example of a SIMPLE splint. When a rotatory displacement has been corrected a plaster cast is needed to hold the reduction. And, in general, a fracture with overlap can only be held reduced by traction.

METHODS OF SPLINTING

The choice depends in the first place on the purpose of the splintage, whether it is being used to keep the bone ends still or to maintain reduction, and second, on the type of displacement. The available methods are:

19

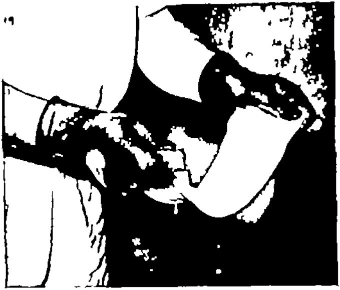


Fig 19 Plaster slab Note how wet it is.

1 *Immobilisation of neighbouring joint*

This is a useful form of SIMPLE splintage when the fracture is near a joint and angulation only is to be controlled. It is used for a supracondylar fracture of the humerus.

2. *Plaster slab*

Plaster-of paris strips, or slabs as they are often called, have almost entirely superseded wooden and metal gutter splints. Excellent bandages ready for use are now on the market. Plaster slabs have their limitations. Although they control angulation they do not control rotation or prevent overlap and they only serve as SIMPLE splints, for they do not keep the bone ends still.

The slab should be applied while still wet and limp if the plaster has begun to set before it is applied it cannot be evenly moulded to the limb (fig 19) It is *advisable to bind* on the plaster slab as tightly as possible, and then in five minutes when the plaster has set to remove the tight bandage and replace it with a loose bandage.

3 *Plaster casts*

These serve both as SIMPLE and as PURE splints. A circular plaster containing two angles keeps the ends of the bones still and so qualifies as a PURE splint. A cast with two angles also controls rotation and angulation, but it fails to prevent overlap for which only continuous traction is of any value.

The less padding there is between the plaster and the skin, the better the

Fig 20 Skin traction. *a* (*top*) steps in application *b* (*below*) in action.

tight circular plaster soon after an accident *All circular plasters should be split down to the skin from the top to the bottom* If the doctor fails to do this and an ischaemia develops he will be blamed even though the ischaemia did not result from too tight a plaster He must be able to prove that the plaster was not the cause of the ischaemia, and he cannot do this unless he has cut a strip out of the plaster

Stockinette should always be used under plaster Without it the patient suffers agony when the plaster is taken off because the hairs of the skin stick to the plaster and removing the plaster entails pulling the hairs out by their roots.

Few doctors are good at putting on a plaster cast. The secret of success lies in winding on the wool tightly and evenly (and this cannot be done unless the wool is itself wound tightly) and in smoothing with the palm every layer of plaster as it is applied The smoothing moulds the plaster to the limb

4. *Gravity*

In a fracture of the shaft of the humerus, if the wrist is slung to the neck the weight of the arm reduces the overlap Also if care is taken to see that the humerus is vertical gravity corrects any angulation. A collar-and-cuff angulates the humerus and must not be used.

5 *Skin traction*

Like other forms of traction, skin traction only overcomes overlap It does not control rotation or angulation, and of course it cannot act as a PURE splint. Skin traction is less dangerous but less effective than skeletal traction. It has three disadvantages: it impedes joint movement, it requires a large area of healthy skin, and the skin may blister The risk of blistering is reduced if the strapping is made to adhere closely to the skin, and is applied over an extensive area, and if the pull is parallel and not at an angle to the skin

Two strips of two-inch wide zinc-oxide adhesive plaster or Elastoplast, long enough to reach up to the joint above the fracture, are cut and to their ends are sewn pieces of half inch strong tape. If the patient is an adult the limb should be shaved. A ring of Robinson tissue is bandaged firmly round the leg just above the ankle to protect the malleoli and the tendo achillis (figs. 20a, 20b). The adhesive plaster strips are bandaged on firmly and to their ends are attached weights The pull should be parallel to the skin otherwise the strapping gradually pulls away from the skin inch by inch, blistering the skin as it does so

6. *Skeletal traction*

This is the best way of applying traction. It is the most effective, it leaves all joints free, and it is always applicable however low the fracture. Its disadvantage is the danger of sepsis leading to osteomyelitis The pin holes in the skin should be sealed with wool soaked in collodion. Movement of the pin inside

the bone is the strongest inducement to sepsis, since it causes a moist exudate to flow along the track. This makes its way out, unsealing the skin. Once the track is open to the outside infection quickly follows.

Skeletal traction is used only for fractures of the lower limb. It is best applied by means of a Steinmann's pin which is a rigid rod the thickness of a meat skewer. A Steinmann's pin does not require any special instruments for its insertion. The usual sites for its insertion are the upper end of the shaft of the tibia and the body of the os calcis. Before the pin is inserted the leg should be in correct alignment. One's inclination is to place the foot upright and insert the pin horizontally: this causes internal rotation of the lower fragment, since under anaesthesia the femur rolls out. For fractures above the knee the patella should face directly towards the ceiling and the pin should be driven horizontally through the tibia, half an inch behind the crest and one inch below the tubercle. For fractures below the knee the foot should be rotated out 20 degrees and then the pin driven horizontally through the body of the os calcis.

Whenever the skin around the pin holes becomes moist or the patient complains of pain it is a wise precaution to remove the pin, and either to fall back on skin traction or to insert another Steinmann's pin lower down the shaft.

7 *Internal splints*

Screws, nails, and plates all have their uses. Before the advent of antibiotics unabsorbable internal splints were viewed with mistrust on account of the danger of sepsis leading to chronic osteomyelitis, delayed union and stiff joints. Antibiotics have made the use of metals comparatively safe.

Internal splints make the best kind of PURE splintage. Internal splints are also of great value as SIMPLE splints because they enable external splintage to be dispensed with, at any rate for the first few weeks during which time the patient can regain full mobility of the neighbouring joints. Full mobility once regained is rarely lost even though the limb is afterwards immobilised in plaster.

During the 1939/45 war Küntscher popularised intramedullary nailing (figs. 21a, 21b, 21c). A long metal rod is introduced into the medullary canal through a small opening in the cortex towards the extremity of the fractured bone; and after exact anatomical reposition has been obtained, either by traction or at open operation, the nail is driven along the interior of the shaft as far as the metaphysis at the other end. Intramedullary nailing has the advantage over plating that weight-bearing is safe immediately.

STAGE III PROTECTION UNTIL CONSOLIDATION

At the end of stage II the bone ends have joined and they move as one. But the junction is frail and the fracture readily angulates or refractures. Protection against angulation and rotation stresses is required until the fracture is consolidated, i.e. until it is strong enough to stand up to the ordinary stresses of life.

A fracture may not require treatment in stage I or in stage II and yet may

require treatment in stage III the fracture may not need reducing and it may need neither SIMPLY nor PURE splintage, yet protection may be necessary

It is sometimes difficult to know when to pass from stage II to stage III of treatment. One is guided by the clinical feel—are the fragments moving as one?—and by previous experience of that particular fracture. The time-table on page 34 is helpful. Radiography is an uncertain guide. If there is ensheathing callus its amount and density give useful information, but when there is no callus the radiograph affords little assistance unless the fracture line is transverse and the picture has been taken at right angles to the fracture line. When the fracture is spiral or when the radiograph is taken obliquely the gap between the fragments will not be seen clearly and one cannot then form any opinion on whether the gap is bridged by bone.

METHODS OF AFFORDING PROTECTION

One must decide what stresses are to be guarded against, and proceed accordingly

In the upper limb except in two fractures—fracture of the scaphoid and fracture of the shaft of the radius—it is sufficient to avoid heavy use. After a fracture of the shaft of the radius rotation of the forearm must be prevented, and the original plaster extending from below the wrist to above the elbow must be retained during the stage of protection And after a fracture of the scaphoid movement at the intercarpal joint must be prevented, again, the original plaster needs to be retained.

In the lower limb it may be necessary to prevent weight bearing or it may be sufficient to apply a splint to prevent angulation.

Constant supervision is necessary to ensure that protection is adequate; otherwise *secondary malunion* or refracture leading to *non union* may occur insidiously and silently

DURATION OF PROTECTION

This depends on.

Whether the fracture is spiral or transverse After a spiral fracture there is rarely any danger of angulation or refracture, and arbitrarily one reckons that a transverse fracture must be protected for twice as long as a spiral fracture. An oblique fracture ranks as a transverse fracture.

The quality of the callus. If the ensheathing callus is massive the time will be short. If there is not much callus if there is a gap between the fragments, and if apposition is poor on account of a lateral shift, the time will be greater

The amount of stress likely to pass through the fracture In the upper limb this will be much less than in the lower limb and one reckons that one must protect twice as long in the leg as in the arm.

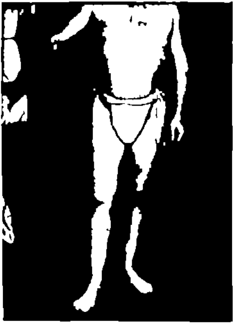
The direction of the stress When stress falls at right angles to the line of fracture little protection is needed. When the stress is parallel to the line of fracture protection is essential. For example, the stress of body weight is

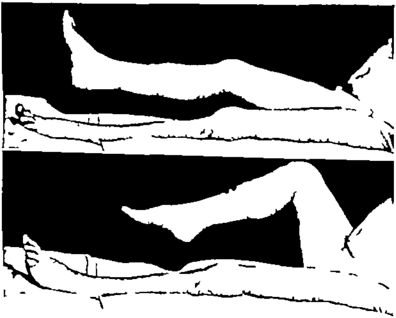
Fig 2 Küntscher nail

a (*above*) Transverse fracture of the shaft of the femur

b (*right*). Nail in position.

(*opposite*) Patient standing fourteen days after the injury (*top*) and (*below*) lifting his leg and bending his knee





parallel to the line of fracture in a transcervical fracture of the neck of the femur and the rotational stress of forearm movements is parallel to the line of a transverse fracture of the radius.

The mobility of the joints above and below the fracture When a joint is stiff it may be easier for movement to occur at the fracture line than at the joint, and this leads to refracture. This is a common cause of non union. For examples, limited extension at the elbow puts a forward angulating stress on a fracture of the shaft of the humerus limited dorsiflexion at the ankle puts a backward angulating stress on a fracture of the shaft of the tibia, and stiffness of the radio-ulnar joint puts a rotational stress on a fracture of the shaft of the radius.

TIME TABLE FOR STAGE II AND STAGE III

For closed fractures uncomplicated by sepsis a rough and ready time-table can be drawn up for the probable time of repair measured in weeks.

	Upper Limb		Lower Limb	
	Union	*Consolidation*	*Union*	*Consolidation*
Spiral fracture	3	6	6	12
Transverse fracture	6	12	12	24

These figures are halved for children.

It will be noted that:

Transverse fractures take twice as long as spiral

Lower limb fractures take twice as long as upper limb.

Consolidation takes twice as long as union.

6

Treatment of the Soft Parts

Severe injuries to tendons, nerves, vessels and skin at the time of the accident rank as complications, and it is tacitly understood that they are excluded when one speaks of the treatment of the soft parts.

A fracture is a dual injury But whereas the damage to the bone is inflicted at the time of the accident the damage to the soft parts is progressive and accumulates throughout the whole time the bone is mending It is largely caused by treating the bone.

Treatment of the bone is the job of the doctor Treatment of the soft parts is carried out by the physiotherapist, but is ordered and should be superintended by the doctor

The physiotherapist has three main tasks.

1 To regain use of the limb
2. To avoid post-splintage oedema.
3 To avoid stiffness.

REGAINING USE OF THE LIMB

This is the most important task because if the physiotherapist succeeds in making the patient use his limb stiffness and oedema are not problems.

Whenever any part of a limb is damaged or becomes painful the limb ceases to function properly and tends to lose recognition in the subconscious mind of the patient. Telephonic communication between the brain and the limb becomes disorganised. Sensory impulses passing up from the limb to the brain are neglected and the forgotten limb is no longer cared for The result is a cold oedematous limb with stiff joints. This can be avoided by making the patient use his limb while the bone is undergoing repair The aim is never to allow the brain to forget the limb's existence. If the physiotherapist succeeds, the brain continues to look after the well being of the limb the muscles automatically function, undergoing shortening and lengthening nutrition is maintained, oedema disappears; and joint stiffness is minimised.

In the arm the problem is simple. The physiotherapist has only to persuade the patient to do something useful with his hands—knit, play the piano peel potatoes—anything, provided that it has a purpose.

In the lower limb the task is more difficult. A leg is used for walking and

the physiotherapist's job is to get the patient walking as soon as possible. After a person has been bedridden for a time he has to accustom himself to the erect posture. He is helped out of bed into a wheel chair and the chair is wheeled to the end of the bed. The physiotherapist then hauls him to his feet and he steadies himself by hanging on to the bed rail with his two hands. Having regained the knack of balancing on two legs he now has to learn to balance on his injured leg. Since in the act of walking one leg is off the ground half the time a person cannot walk properly unless he can balance on one leg, and a patient is fearful of balancing on his injured leg. He must be inveigled into doing this. The physiotherapist proceeds by stages. First, the patient takes a firm grip on the shoulders of the physiotherapist and she a firm hold under the patient's armpits. When the patient first takes his sound leg off the ground he clings desperately to the physiotherapist; soon he learns to balance and is able to take weight when only lightly touching the physiotherapist's shoulders. The patient next proceeds to mark time like a soldier, raising his knees to a right angle to make balancing more difficult. Only when the patient is able to balance is he allowed to walk.

Sometimes a patient is able to get up but the union is not solid enough to take weight. In that case the patient is taught 'shadow walking'. While taking weight on his crutches he is made to go through the normal actions of walking even to touching the ground with his foot. He must not be allowed to swing his leg as though it were jointless.

Many fractures have to be treated for a time in bed. The brain, however, retains control over the limb if the physiotherapist makes the patient repeatedly lift his leg off the bed by his own efforts.

AVOIDING POST-SPLINTAGE OEDEMA

Oedema of a limb after a fracture is caused by three factors: sudden outpouring of fluid into the tissue spaces as an immediate response to injury; mechanical interference with drainage owing to the rupture of veins and lymphatics; and inhibition of the control of the circulation as a consequence of disuse of the limb.

The first factor is temporary. As regards the second factor it would seem that this could only be remedied by the passage of time during which new veins and lymphatics were laid down. In practice, however, active use of the limb and automatic massage by muscle contractions get rid of the oedema and often prevent its reappearance on the removal of the splint. A patient with a fracture below the knee if made to walk normally in plaster has little or no oedema when the plaster is removed. The absence of oedema in a limb whose function has been maintained while the bone was mending demonstrates that the oedema is due less to mechanical interference with the circulation than to loss of control of the circulation. Not knowing much about the mechanism that controls the passage of fluid to and fro between the vessels and the tissue spaces we are apt to forget the existence of a controlling mechanism. What is

certain is that if a limb or part of a limb ceases to function, control of the circulation is upset. Everyone is familiar with the rush of blood to the feet experienced by a person on first standing after being in bed with an illness.

Use of the limb during bone repair is of supreme importance in preventing post-splintage oedema.

AVOIDING STIFFNESS

Moving a joint through its full range keeps it supple, and the physiotherapist ought to make the patient move fully all joints that are not splinted. The operative words are *make the patient* It is not the job of the physiotherapist to move joints for the patient; her task is to make him move his own joints. So-called passive movements become forced movements unless the patient is able to relax his muscles completely—not an easy thing to do when one is expecting to be hurt. Forced movements are dangerous only after the bone has consolidated are they safe. If used before, they are likely either to refracture the bone if bony callus has started to form, or at an earlier stage to induce fibrous union by imposing a hinging stress on the repair material.

Muscles under splints cannot be stretched to their full, but the ability to lengthen is preserved if postural activity of muscle is inhibited from time to time. And so the physiotherapist makes the patient try to move the joints that are under splints. In willing the joint to move, the patient automatically relaxes one set of muscles while the other set is contracting

When the time comes to remove the splint the physiotherapist can use massage, faradism and heat. Faradism strengthens the muscles, and after the application of heat the patient finds it easier to move his joints. For the extremities wax-baths are valuable. Massage with oil or soap removes dead scales from the skin. Massage is also useful in mechanically assisting the return of fluid from the stagnant veins and lymphatics.

In stage IV of treatment, after the fracture has consolidated, manipulation of the limb under anaesthesia to stretch the muscles and joint capsules is sometimes done. It is doubtful whether it is any more useful than ordinary use of the limb in removing stiffness.

The footballer though fit, is not fit enough to play rugger in early October unless he goes into training Similarly many patients need to train before they are capable of returning to their former work. A man with a broken leg which has joined in good position and who has regained full movement of all his joints, must strengthen his muscles before he can start doing heavy manual work all day long This needs the co-operation of the man s employer

It is now possible to sum up the treatment of the soft parts and integrate it with the treatment of the bone.

		Bone	*Soft Parts*
Stage	I	REDUCTION	Nil
	II	SPLINTAGE until UNION	Make the patient: Use the limb Move all free joints Contract all muscles
	III	PROTECTION until CONSOLIDATION	Make the patient: Use the limb Move all joints Massage Faradism Heat
	IV	Nil (Bone repair complete)	Manipulation under anaesthesia if required Training to get fit for work

7

Treatment of a Fracture into a Joint

Accurate reduction is not essential for a fracture of a shaft, but it is highly desirable in a fracture that involves an articular surface; for unless reduction is meticulous the opposing articular surfaces do not afterwards fit one another. Exact anatomical reposition can rarely be obtained by closed manipulation because the articular fragment is small and uncontrollable from without. Whenever it is possible to get exact reduction at an open operation internal fixation is the best treatment. The method is most useful at the ankle. It should be noted that there is seldom any point in using internal fixation unless exact anatomical reposition has been obtained.

Even at operation reduction often proves impossible, especially when the surface is comminuted. If however the injured joint is allowed and encouraged to move, movement moulds the broken articular surface so that it comes to fit its opposite number. Therefore *fractures into joints should not be immobilised if it can be helped.*

Failing internal fixation, the second-best treatment is to combine traction with movement. Traction maintains a fair reduction and at the same time enables the patient to move his joint without pain (fig. 197). This method is used for nearly all fractures into the knee joint.

The third treatment, of limited application, is to make a new joint by excising the end of the broken bone. This is a gratifying procedure when the head of the radius has been smashed.

Sometimes in spite of treatment the opposing articular surfaces remain incongruous, and the patient is crippled with a painful joint of limited range. Arthrodesis of the joint is then indicated.

8

Open Fractures

A fracture is *open* when there is a breach of the skin and *closed* when the skin is intact. Open fractures are of three kinds, which differ greatly in their seriousness.

1 Direct open, in which the skin is cut from without by the force causing the fracture.

2 Indirect open, in which the skin is punctured from within by the protrusion of the end of a bone.

3 Secondary open, when the skin sloughs some time after the injury

DIRECT OPEN FRACTURE

A direct open fracture complicates treatment on account of potential sepsis, destruction of soft tissues, and the difficulty of splinting in the presence of a wound.

THE PREVENTION OF SEPSIS

In a direct open fracture every precaution against sepsis should be taken (1) by ridding the wound of bacteria, (2) by removing all culture media from the wound and (3) by converting an open into a closed fracture at the earliest possible moment.

This calls for immediate operation. The operation is known as a wound toilet. A wound-toilet should be done as soon as possible; every hour counts, an open operation should rank as a surgical emergency There is no need to postpone operation on account of shock because shock often passes off during anaesthesia. The injured part should not be disturbed nor should an X ray be taken until the patient is in the theatre.

The wound will probably need enlarging, and the skin incision should be generous. Fascial planes are divided, if need be, to make the toilet thorough.

Antiseptics are of no use in getting rid of bacteria because if strong enough to kill them they also kill the cells of the body and the dying cells act as a culture medium for the bacteria that survive. Reliance must be placed on physical means; pieces of clothing and other foreign material are removed, and the wound is washed out with saline.

Non-viable tissue must be excised. This is the important part of the opera

tion for although one may not be able to kill bacteria one can starve them, since they derive their nourishment from dead tissues. The difficulty is to know which tissues are dead or are likely to die: especially is this so with skin. A scalped skin on a limb will die unless the base of the flap is at least as wide as its length. If in doubt the skin should be sacrificed.

Detached tags of muscle and avascular muscle should be removed. Fascia should be incised so that fluid cannot collect under tension. Divided tendons and nerves are lightly drawn together but formal suture is not attempted. Only bone fragments that are completely detached should be removed. The object of the wound toilet is not to shave off a thin layer from all contaminated tissues but to remove all dead tissue and all tissue so badly damaged that it is likely to die. All bleeding should be stopped to avoid leaving a haematoma for the bacteria to feed on. The wound is sewn up so long as skin has not been lost or sacrificed. Skin edges should not be drawn together under tension, and when skin is missing it is better to fill the gap with a split-skin graft.

Antibiotics and antitetanic serum should be given to all patients with direct open fractures.

Established sepsis

The infections in descending order of severity are due to anaerobes, tetanus bacilli, streptococci and staphylococci.

Anaerobes. An anaerobic infection is always to be feared in an accident in a farming district or in a war wound. The organisms are of various kinds. Probably they are frequently present in open fractures but are unable to thrive except in the presence of dead tissue. They produce gas in the wound, death of the muscles, and severe toxaemia—a clinical condition known as gas gangrene.

The onset of gas gangrene is fulminating—within a few hours of the accident—and the infection spreads like a bush fire. The patient is very toxic and exudes a characteristic odour which pervades the whole ward. He complains of severe pain. The area of the wound is diffusely swollen, the skin has a marbled blanched appearance, a thin watery fluid escapes from the wound and bubbles of gas can be felt as crepitations under the skin. The established disease is unmistakable.

Antigas sera and penicillin are pumped into the patient. The fracture area is widely laid open and all devitalised tissue removed. Devitalised muscle is pale, does not bleed when cut across, and cannot be made to contract. The wound is left open. If within the next few hours the toxaemia is no less and the area over which crepitations can be felt is increasing the limb should be amputated at a level that will not leave any infected tissue. Ordinary skin flaps are cut but the skin is not sutured.

The severe infection described above is rarely seen in peace and only in war time when the medical services break down, as for example during a retreat.

Tetanus. Tetanus develops under conditions that favour gas gangrene. It has become rare in civilian life since the routine administration of antitoxin after

all open wounds, and in the future tetanus toxoid will make it rare even in war. Tetanus begins with rigidity of the local muscles. General rigidity follows.

As soon as tetanus is suspected large does of antitoxin should be given intravenously and the dose repeated daily. It is important to relax muscle spasm so that the patient is able to breathe and swallow. Muscular spasm is controllable by intravenous transfusions containing drugs such as myanesin. Treatment is very much in the hands of the anaesthetist nowadays. The wound should be laid open.

Streptococci. Whereas gas gangrene develops in a few hours streptococcal infections take a few days. Infection is often introduced with a rigor. The temperature rises and the patient becomes ill. Locally there may be only a little swelling and redness of the skin but there is severe pain and tenderness. Antibiotics are given freely. A residual abscess may need opening.

Staphylococci. Symptoms do not usually appear for a week. There is local red swelling and tenderness in the neighbourhood of the wound and often fluctuation in an infected haematoma. The temperature may be high but the patient is not very ill. Evacuation of the pus through a small skin incision is usually sufficient.

Pyogenic infections are at first confined to the soft tissues but quickly spread to bone and to the neighbouring joint if the fracture has penetrated it.

In the treatment of an osteomyelitis due to the infection of an open fracture there is no need to drain the bone because this has already been done by the fracture. For practical purposes one is dealing with sepsis of soft parts, with the exception that in the later stages a sinus may persist on account of sequestra that require removal. Usually the fracture remains ununited until the sepsis has been overcome and the wound has healed. It may then unite, but occasionally the bone ends must first be exposed and their cap of scar tissue removed.

Unlike an infected bone, an infected joint may require opening. Afterwards, the joint should be splinted in the optimum position for ankylosis lest that happens.

DESTRUCTION OF SOFT TISSUES

The immediate problem is to decide whether the limb is viable. A limb should not be sacrificed lightly. The deciding factor is the patency of the main vessels. So long as the distal portion of the limb is being supplied with blood it should be retained. Should the distal circulation fail, the limb is amputated at the site of election and the skin is sutured.

Definitive repair of soft tissues should not be undertaken until all risks of sepsis have passed. The divided ends of nerves and tendons if come across at the wound toilet operation should be lightly joined together with a few interrupted sutures, but no attempt should be made to search for divided ends. Sepsis may postpone the repairing of soft tissues for months.

DIFFICULTY OF SPLINTING

Overlap can be controlled by skeletal traction and other displacements by a plaster cast, often the two are combined. The plaster is split from top to bottom as usual, in addition the two sides are sprung apart so that there can be no risk of further death of tissue from obstruction to the circulation. A window is cut in the plaster for the inspection of the wound, although the dressings are disturbed as seldom as possible. With every dressing there is a risk of infecting the wound.

Attempts to improve the position of the fragments should be postponed until sepsis has been eliminated. Internal fixation should not be used in the presence of actual or potential sepsis.

INDIRECT OPEN FRACTURE

Whereas a direct open fracture is a potential danger an indirect open fracture is of little moment. Sepsis is unlikely because there is not any devitalised tissue and in the absence of devitalised tissue a wound toilet operation is not required. Harm is often done by unnecessary surgical interference in the belief that *all* open fractures demand a wound toilet. There should however be no hesitation in operating if there is the least chance that soft tissues have been devitalised.

When the bone has withdrawn into the interior nothing need be done beyond placing a small dressing over the skin puncture. When the bone is still protruding it is washed with saline before being replaced under the skin. It is not necessary to excise the protruding portion and antiseptics do more harm than good. A small window is cut in the plaster over the wound, although usually the dressing does not need to be disturbed until the skin has healed. The soft tissues are not damaged more than with a closed fracture and do not require specific treatment. Prophylactic antibiotics should be given.

As soon as the bone has withdrawn into the interior the fracture is treated as a closed fracture. There are not any problems of splintage.

SECONDARY OPEN FRACTURE

The skin may be broken by a splint sore or by the bursting of an infected haematoma or the skin may die from the cutting off of its blood supply. Blisters should be pricked with a sterile needle and the fluid expressed and the raw area swabbed with iodine and covered with a dressing.

Splint sores must be guarded against. *If a patient complains of localised pain under a plaster the skin in that region must be exposed.* Pain indicates that the skin is being crushed. If the pressure is not relieved the skin sloughs, and although the pain then ceases the ulcer is liable to get infected with tragic consequences.

The contents of a suppurating haematoma may burst through a small hole in the skin. The small wound should be covered with a dressing

Much the most important secondary open fracture is met with after a run-over accident. The force is a combination of a crush and a roll. The rolling force *is apt to pull the skin away from the deep fascia and destroy its blood* supply. The damage to the skin is not obvious at first. A few days later a large area of skin goes black (fig. 22).

Dead skin is dangerous. It should be removed immediately and replaced by a skin graft. One should not wait for an obvious slough to appear for sloughing is bound to be accompanied by infection.

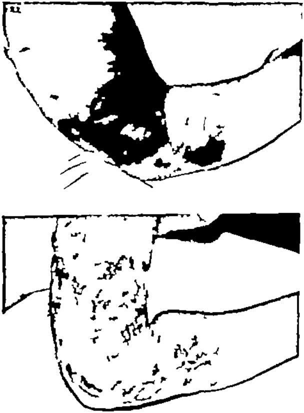


Fig. 22. Secondary open fracture. *Above*: as a result of a runover injury an area of skin has died. *Below*: dead skin has been excised and the raw area covered with a graft.

Fluid everywhere leaks out of the blood stream into the tissues, producing oedema and serous effusion. Organs starved of blood cease to function, the urine for instance becomes scanty and contains red cells, albumin and casts, and the blood urea mounts.

There are three types of shock: neurogenic, haemorrhagic, and toxaemic.

Neurogenic shock

At any one time most of the arterioles are constricted and only those needing at the moment a liberal supply of blood are dilated. The muscles in the arterial walls may however be put out of action temporarily by strong stimuli impinging on the nervous arc that controls the state of their constriction, in which case all the vessels dilate at the same time. In consequence the total blood volume is insufficient in amount to fill all the vessels, and a state of shock appears.

Neurogenic shock happens when the constrictors are inhibited by strong emotional stimuli such as pain and fear The reaction is sudden and rapid. It follows immediately after the exciting cause, and for this reason is called primary shock. Neurogenic shock is short lasting A person may faint from an insufficient supply of blood to the brain on hearing bad news, but consciousness is quickly recovered.

Neurogenic shock is usual even after the simplest fractures, and is often overlooked. At the time of the accident the patient goes white, feels faint, and is often sick. If available, morphia should be administered at once to relieve pain and so mitigate shock.

Haemorrhagic shock

When the wall of an artery is perforated blood leaks out and the blood volume diminishes. The loss cannot be made good rapidly because fluid can only enter the capillaries if attracted there by osmotic pressure.

With an open fracture and even with a closed fracture blood loss may be considerable, and the patient may be in haemorrhagic shock on arrival at hospital, if he is, a transfusion should be started before the fracture is reduced.

Toxaemic shock

At one moment fluid may be passing into the circulation to restore volume and at another plasma may be passing out of the circulation in response to a local injury This in-and-out flow is controlled by the relative osmotic pressures of the blood and the tissue spaces. The permeability of the capillary wall is another factor Certain poisons (snake venom and histamine for example) destroy the selectivity of the membrane and convert the capillaries throughout the body into simple filters. Several hours after a fracture a patient may pass into shock in spite of not having lost any blood. This type of shock, which is

often referred to as secondary shock to distinguish it from primary or neurogenic shock, is due to an alteration in the permeability of the capillary walls. It is supposed that toxins from tissues devitalised by the accident are responsible for toxaemic shock.

The term traumatic shock signifies that the shock has been preceded by trauma, it does not indicate whether it is neurogenic, haemorrhagic, or toxaemic. After any injury the state of shock should be assessed. In particular one must form an opinion on whether shock, if present, is *compensated*, *uncompensated* or *irreversible*

The treatment of shock depends on its cause. Pain and loss of blood are the two main factors in post traumatic shock. Pain should be relieved by morphia and lost blood should be made good by a blood transfusion.

It is important to realise that, in all degrees of shock, treatment is given to prevent something worse happening The condition of the patient when first seen may not appear too bad and the urgency of treatment may not therefore be appreciated.

2. FRACTURE FEVER

Usually the temperature is raised for a day or two perhaps to 100 degrees.

3 FAT EMBOLISM

This is rare but often lethal. It occurs within the first few days. How and why the fat gains an entrance into the circulation is not known. Globules of fat are arrested in the capillaries throughout the body and there set up an intense haemorrhagic reaction. The clinical manifestations are many: 1 Sudden death, probably from damage to the heart muscle. 2 Unexplained persistent shock associated with a rapidly progressing anaemia, caused by myriads of tiny haemorrhages. 3 Cerebral irritation and coma, from small haemorrhages around fat globules in the brain And 4, the lung alveoli become clogged with a haemorrhagic exudate, which the physician usually diagnoses as pneumonia.

The condition is likely to be missed and death to be attributed to shock, and unless a special search is made fat embolism is not detected at a routine autopsy Should the diagnosis be suspected petechiae in the skin of the chest wall and in the conjunctivae should be looked for: they are nearly always present. Most patients recover after a few days of coma or lung consolidation. Probably many minor cases escape recognition.

There is no specific treatment. In view of the anaemia repeated blood transfusions should be given.

4. PULMONARY EMBOLISM

This is not uncommon. It does not differ from that following operations. Luckily the effects are usually trivial.

LOCAL COMPLICATIONS

1 INJURY TO INTERNAL ORGANS

When an internal organ is damaged the injury to the bone is of secondary importance. Damage to the brain is associated with a fractured skull, pneumothorax and haemothorax with fractured ribs, paraplegia with a fractured spine and rupture of the urethra with a fractured pelvis.

2. INJURY TO VESSELS

Four things may happen. A large artery may be divided, giving rise to severe haemorrhage. The main artery may be divided, threatening gangrene. The main artery may be constricted by spasm, causing ischaemia. And the blood supply to one end of the bone may be destroyed, giving rise to aseptic necrosis.

Haemorrhage

When the haemorrhage is internal, as in a closed fracture, bleeding stops automatically as soon as the tension in the tissues rises high enough. There is a slight danger that the high tension will compress the other vessels and interfere with the supply of blood to the limb Nothing however needs to be done so long as the extremity of the limb has an adequate circulation

When the haemorrhage is external, as in an open fracture, pressure applied over the wound will always stop the bleeding Pressure applied at the site is as efficacious as pressure applied more centrally by means of a tourniquet, and is less likely to endanger the vitality of the limb At the wound toilet operation the bleeding vessel must be sought for and tied. Since it is impossible to gauge how much blood has been lost a blood transfusion should be given in all cases where there has been external haemorrhage, even though the patient's appearance may not suggest that he has lost a lot.

Threatened gangrene

One or more of the main vessels of a limb may be divided. An artery if completely severed quickly seals itself and bleeding may not be severe. Usually in spite of the cessation of flow in the main vessel the limb receives sufficient blood via collaterals.

It is of the utmost importance to know whether a limb peripheral to a fracture is receiving enough blood. In case of potential gangrene pain is intense. But the pain passes off as the nerves are put out of action by the ischaemia. Colour changes are important. There is immediate blanching of the whole limb followed by a distal cyanosis which gradually spreads upwards. The vessels in the skin reflexly dilate and the blood inside them rapidly loses its oxygen, hence the cyanosis. Some hours later the cyanotic areas are broken up by white patches where the blood in the skin has passed on into the deep veins. The vessels become porous and the exuded blood shows up clearly as streaks, giving the limb a mottled appearance. The surface temperature rapidly falls

and the skin feels very cold Oedema is usual but may be absent if the limb has been elevated it is caused by an escape of blood and plasma into the tissues and is most marked where there is still a trickle of arterial blood. The distal pulses disappear at once. With the establishment of a good collateral circulation the pulse may return in four days at the wrist and in fourteen days on the dorsum of the foot; yet even when an adequate circulation is restored the pulse may never reappear Local return of colour after momentary pressure on the skin is not a good guide to the state of the circulation A more reliable method is to empty a superficial vein by massage and to note how long it takes to fill. Sensation remains unaffected for fifteen to thirty minutes after the cutting off of the blood supply then hypoaesthesia passing on to anaesthesia replaces normal sensation The loss is not confined to the area of any one peripheral nerve, and on that account can be distinguished from local injury As the circulation is re-established paraesthesia appears. Recovery after complete interruption of sensation takes many months and is usually only partial The muscles may likewise function normally for some minutes paralysis then sets in to be followed within a few hours by contracture.

The extent of the gangrene cannot at first be gauged. While the syndrome of pallor cyanosis, coldness and absent pulse render it unlikely that a collateral circulation will be re-established, hope need not be abandoned until a line of demarcation appears.

Treatment for threatened gangrene The first task is to restore the general circulation to its normal state of efficiency As a consequence of shock the blood pressure is low and there is reflex vasoconstriction of all the arterioles in the limb and as a consequence of haemorrhage the oxygen carriers in the blood are low in number For these two reasons a rapid transfusion of several pints of blood should be given immediately

At the very best the amount of oxygen reaching the limb will be small and the utmost economy in its use is called for The limb should be at rest and should be kept cool since metabolism varies with temperature. The limb is exposed, and an electric fan placed near it if the room is warm. Nothing must be done to impede the circulation in the collateral vessels. Circumferential pressure must be avoided and a plaster cast is contraindicated. Skeletal traction should be relied upon to splint the fracture.

Elevation of the limb helps to reduce oedema and so to remove pressure from the collateral vessels.

Vasodilatation of the collaterals is desirable. Smoking causes vasoconstriction but in a heavy smoker its sedative effect may offset this. Sleep is an effective vasodilator and phenobarbitone should be given in regular doses. Vasodilator drugs are of doubtful value. Papaverine sulphate applied locally to the wall of a vessel relaxes spasm, but it has no effect if given intravenously

Ischaemia

When a vessel is injured by the end of a broken bone it goes into spasm, which lasts from a few hours to a few days. The spasm spreads to the collateral vessels if they arise near where the main artery is damaged. This happens at the elbow and the resulting ischaemia has serious consequences (Volkmann's ischaemia)

It is common practice to treat elbow injuries with the elbow in flexion. With the elbow flexed the radial pulse often cannot be felt at the wrist. This is not alarming provided that the patient is not complaining of great pain and can move his fingers and that the colour of the skin on the hand is good. Severe pain, a dusky skin and fixed flexed fingers indicate that Volkmann's ischaemia is imminent.

Treatment must be prompt and thorough. First the elbow should be lowered to a right angle and any encircling bandage or splint removed. An X ray should then be taken. If the radiograph shows that the fracture is unreduced and that the upper end of the shaft of the humerus might be pressing on the brachial artery another attempt at reduction should be made. If within an hour of a successful reduction the circulation has not recovered the supposed site of the arterial obstruction must be cut down on. Incising deep fascia relieves tension and may well make all the difference to the struggling circulation. Exposure of the damaged vessel and the removal of the superimposed blood clot sometimes gets rid of the spasm. It has been advised that the main vessel if found tightly in spasm should be divided and its two ends ligatured. This paradoxical treatment is supposed to increase the blood supply to the limb by reflexly freeing the collaterals from spasm. It would seem better to be content with relieving pressure and with the application of a 2½% solution of papaverine sulphate to the outside of the vessel.

Aseptic necrosis

Apart from interference with the main supply to the limb the entire blood supply to one bone fragment may be cut off and the fragment dies. This is known as aseptic necrosis of bone. Aseptic necrosis although it dates from the time of the accident does not reveal itself for several months. Clinically therefore it is a late complication.

3 INJURY TO NERVES

The main nerves should always be examined after an accident. Immediate recognition of damage to a nerve is not essential for treatment, but the doctor is apt to be blamed for the damage if he is not in a position to point out that it was present when he first saw the patient.

The nerve may be injured by crushing, by stretching or by being impaled on the sharp edge of a bone fragment. The nature of the accident often enables one to decide whether the nerve is likely to have been divided and so, whether

suture is necessary In any case exploration of the nerve is postponed until the bone has united.

4. INJURY TO JOINTS

A dislocation if present should be reduced before the fracture is treated. A haemarthrosis if tense is aspirated.

5 INJURY TO TENDONS

These are common in hand fractures caused by circular saws At the wound toilet operation divided tendons if come across are sewn together but if the ends do not come to hand they are not searched for Definitive repair of tendons is postponed until the fractures are mending and the skin has healed

6 INJURY TO SUBCUTANEOUS TISSUES

Sometimes a run-over injury destroys the blood supply to a large area of subcutaneous tissue. The bone underneath may or may not be broken. The skin and subcutaneous tissues are detached from the deep fascia as though they had been stripped. The subcutaneous tissue and later the overlying skin undergoes necrosis. All devitalised tissue should be removed at the wound toilet operation and the skin defect made good at once by a skin graft. Sometimes one gives the skin the benefit of the doubt. But the wound should be inspected in two days time and any black skin should be replaced forthwith by a skin graft. If the apparently harmless black scab is left, sepsis is almost inevitable, and this may lead to further loss of skin (fig 22)

10

Remote Complications of a Fracture

1 MALUNION

There are two kinds of malunion, primary and secondary *Primary malunion* is due to faulty reduction the fracture never was in good position. *Secondary malunion* is due to faulty splintage or faulty protection, the displacement after being accurately reduced recurs, either during stage II of treatment because splintage is inadequate to hold the reduction or during stage III because stress is allowed to pass through the bone before the fracture has consolidated.

Treatment of malunion

Malunion may call for treatment for one of three reasons, cosmetic, actual loss of function, and potential loss of function.

One should consider first whether the patient's complaints are related to the malunion often they are due to some other cause. Next, one identifies the element of the malunion that is responsible for the symptoms and finally one considers how that particular element can be corrected The patient's symptoms are sometimes better treated otherwise than by correction of the deformity: for instance, when a cubitus valgus is causing an ulnar nerve paralysis, it is easier to transpose the nerve to the front of the elbow than it is to osteotomise the humerus.

In stage II the callus is still soft and malleable and the deformity can be corrected by manipulation under anaesthesia. In stage III the fracture has consolidated and deformity can only be corrected by osteotomy

2 NON UNION AND DELAYED UNION

Experience tells us that any given fracture unites and consolidates in a certain time (see time-table on page 34). If a fracture is not consolidated by the end of this period there is *delayed union*. If the delay is prolonged indefinitely there is *non-union*. Usually the two ends are joined by fibrous tissue and non union should correctly be called fibrous union. Rarely there is a gap between the fragments filled with a slippery fluid, the term pseudarthrosis is then used. In common parlance non-union is taken to mean that the bones are joined, but are joined by fibrous tissue instead of by rigid bone.

Although the causes of delayed union and established non union are in general the same it is important to separate their treatments.

Usually only the passage of time allows one to transfer a fracture from the delayed-union to the non union group The presence of a painless hinge renders it unlikely that the two ends of a fracture will join by bone· there is non-union. If the hinge is painful there is still a chance that the two fragments will join by bone; union is perhaps only delayed. The only sure sign of established non union is the appearance in a radiograph of a thin cortical shell of bone sealing the ends (figs. 23a, 23b).

The causes are conveniently divided into unavoidable, and avoidable.

UNAVOIDABLE CAUSES

Four conditions are essential for bone repair· a healthy body a healthy bone a normal blood supply and a proper supply of bone salts. Theoretically therefore non union might be due to general disease, local bone disease, interference with the blood supply to one fragment, and a deficiency of bone salts.

General disease

It is doubtful whether this is ever a factor Old age is no bar to union, in fact non-union of the shaft of a bone is rare except in a healthy young adult. Debilitating illnesses such as diabetes and nephritis have been unfairly blamed. Probably the only general disease that impedes repair is syphilis in its tertiary stage.

Bone disease

None of the dystrophies impedes repair Osteomyelitis retards union in the acute phase because the repair tissue is dissolved away in pus and the ends of the bones become sealed with fibrous tissue· and in the chronic phase on account of a diminished blood supply A fracture through a sarcoma does not unite because the repair tissue is eaten away as soon as it is formed, a fracture through a secondary deposit unites although the bone often breaks again.

Interference with the local blood supply

Thrombosis of the main artery to one fragment is a cause of non union. Nevertheless even though the blood supply to one fragment is totally cut off union is not impossible; it will however be delayed. Failure of the blood supply can be recognised in a radiograph some weeks after the accident. Ordinarily after a fracture both fragments atrophy and so cast a light shadow· a fragment deprived of its blood supply casts a heavy shadow

The bone cells in the bloodless fragment die and the fragment behaves like an autogenous bone graft. The process is called *aseptic necrosis of bone* (fig 24). The dead portion may remain as a sequestrum, which the living cells around try to extrude; or circulation may be gradually re-established and the dead bone replaced piecemeal by living bone. Aseptic necrosis is seen most often in the proximal fragment of a fractured neck of femur and in the proximal fragment of a fractured scaphoid.

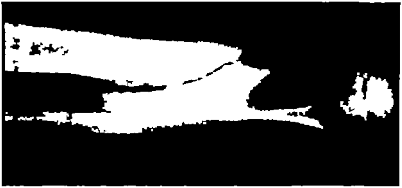


Fig 23b Non-union.

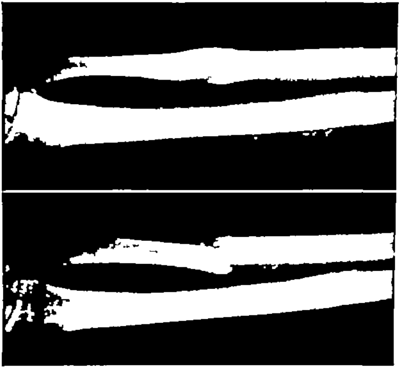


Fig 23a. Delayed union. *Left* three months after the injury
right ten months after the injury

When aseptic necrosis occurs the splintage and protection stages must be continued for longer than usual, until in fact it appears from the radiograph that the dead bone has been replaced by living bone It may lengthen the time of repair fourfold.

Deficiency of bone salts

Lack of bone salts, their presence in incorrect proportions and the lack of phosphatase are doubtful factors. The administration of calcium although rated highly by the public does not influence the speed of repair Rickets and osteomalacia do not cause non-union.

AVOIDABLE CAUSES

These are inadequate reduction inadequate splintage, and inadequate protection.

Inadequate reduction

A fracture will not join by bone unless the fragments are touching Non-apposition is caused by excessive traction, by destruction of bone, and by the interposition of soft parts.

Excessive traction. When the muscles are stronger than the traction the broken ends are pressed together and repair by bone is probable. When traction is stronger than the muscles the broken ends are being pulled apart, and repair by fibrous tissue is probable.

Anxiety to avoid shortening is often responsible for non-union. A small amount of shortening is immaterial, the patient is unconscious of it and it can only be discovered by careful measurements. The lay public needs to learn that minor degrees of displacement and slight overlap do not lead to disability but on the contrary are an insurance against non union. Non-union is likely when reduction is anatomically perfect and is being maintained by traction. It is always safer to have a slight amount of overlap in a fracture of a shaft.

Destruction of bone There may be massive destruction of bone in osteomyelitis (rare nowadays), and a large part of the shaft may be lost after a gun shot wound. Gross destruction of bone is only responsible for non-union in the forearm and leg where the intact fellow bone prevents approximation of the bone ends by the muscles.

Interposition of soft parts The frequency of this is overrated. At operation for non-union one may find fibrous tissue between the ends but this is more likely to be the result of organised blood clot than of muscle included at the time of the accident. In a longitudinal fracture of the shaft of the femur due to a fall from a height the sharp end of one fragment may penetrate the muscles, but this is not a common fracture.

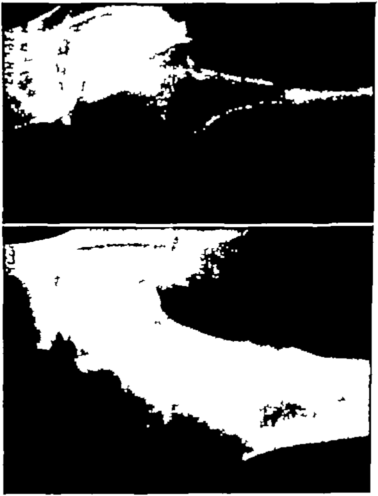


Fig. 24. (*left*) Aseptic necrosis of the head of the femur (*right*) normal head.

Fig 25 Myositis ossificans.

Inadequate splintage

Certain fractures demand PURE splintage to prevent hinging and rotation at the site of the fracture. If a SIMPLE splint is used in place of a PURE splint in these fractures the broken ends move on one another and stretch the repair material And stretching leads to the formation of fibrous tissue instead of bone. Tonic activity is not strong enough to prevent movement at the fracture site if the bone is continually hinged by outside forces or by injudicious active movements.

Inadequate protection

This is the most insidious cause of non union and the one least appreciated. Protection may be inadequate in extent or time. The fracture has united but too much stress is allowed to pass through the bone and the callus breaks. The refracture passes unnoticed and is therefore untreated. With continual use of the limb the fracture site is submitted to continual hinging and fibrous union results. This is common with a fracture of the shaft of the femur The patient is allowed up in a Thomas a caliper—a splint that is not able to protect the fracture site from angulating Although weight bearing on a straight bone produces bony union, weight bearing on an angulated bone produces fibrous union.

TREATMENT OF DELAYED UNION

General treatment is of doubtful value, but is expected by the public. A diet rich in proteins is ordered and cod liver-oil and calcium are given by mouth.

In the past, two forms of local treatment were popular Under an anaesthetic the bone ends were hammered or ground together this produced a haemorrhage around the bone ends and fresh callus was laid down in the new clot. Alternatively the blood supply to the area was increased by passive congestion. Active use of the limb does this quite as well and is simpler

Probably the only treatments worth while are to compress the site of the fracture by making the patient take weight on his limb and by making him contract the overlying muscles, preferably by active use of the limb

The knowledge that union is tardy often enables a surgeon to prevent delayed union going on to non union by prolonging the period of protection.

TREATMENT OF NON UNION

This may be summed up as follows: raw the bone ends and bring them into apposition, then treat as for a recent fracture, namely by splintage until union and by protection until consolidation.

Rawing the bone ends

The fibrous tissue covering the ends of the bones must be removed at an open operation. As sepsis is likely if the wound does not heal per primum, operation

should be postponed until all sinuses have healed and until the skin is healthy It is often wise to excise the scar and skin graft the area at a preliminary operation.

Apposing the bone ends

In a recent fracture the overlying muscles can be relied upon to bring the bone ends into contact. In non-union associated with a gap it is asking too much of the muscles to do this, and when there is an intact fellow bone the muscles are given an impossible task. In the lower limb the ends of the tibia can be brought into contact by division of the fibula, in the forearm (and sometimes in the leg) it is better to leave the fellow bone intact and to bridge the gap with a bone graft.

Splintage until union

In the treatment of a fracture a graft is never strong enough to replace a splint. In non-union the task of a graft is linkage not splintage. External splintage is better than internal fixation, which tends to hold the bone ends apart. Plating an ununited fracture is doomed to failure.

Protection until consolidation

This does not differ from the treatment for a recent fracture. But as the cause of the non union may have been a refracture resulting from failure to protect for long enough or securely enough, care must be taken not to make the same mistake again. It is wise to double the time of both stage II and stage III in treating an ununited fracture.

3 JOINT STIFFNESS

Loss of movement from inextensibility of muscles and shrinkage of the capsule has been considered on page 17 Should they occur treatment has usually been faulty But with a fracture near a joint, especially the elbow repair material may encroach on the capsule. The radiograph often shows patches of calcification in the capsule. It is not known how to avert stiffness from this cause.

4 DEGENERATIVE ARTHRITIS

A joint may age prematurely when there is abnormal strain on its capsule from malunion of the fracture of the shaft. Degenerative arthritis also follows aseptic necrosis and incongruity of the opposing articular surfaces. "Traumatic arthritis without a cause is not common.

5 INTERFERENCE WITH GROWTH

This is liable to happen whenever a fracture line passes through a growth disc, and it is surprising that it is not more common. It is seen most often (and that only rarely) at the lower end of the tibia. The fracture line runs partly through

the growth disc and partly through the metaphysis (fig 242) One half of the growth disc afterwards continues to grow normally and in the other half growth is stunted. The result is a marked deformity of the foot. Similarly injury to the lower epiphysis of the radius may result in a deformity of the wrist.

It is possible that some cases of varus deformity of the elbow are caused by interference with growth but the majority are certainly due to faulty reduction of a supracondylar fracture of the humerus. An unreduced fracture of the lateral condyle leads to a valgus deformity which increases throughout the period of growth.

6 MYOSITIS OSSIFICANS

Sometimes after an injury the muscles exhibit a state of extreme irritation. They go into spasm and prevent all movement Two or three weeks later a radiograph shows a calcified mass in the substance of the muscle (fig 88) The nature of the condition is not known It is seen most often after a kick on the thigh and then is not accompanied by a fracture (fig 25), so that it is unlikely that the new bone is derived from osteoblasts that have wandered from beneath the periosteum. In the course of weeks the irritation passes off and movement returns. The calcified mass gradually diminishes in size but gets more distinct in the radiograph

In the irritable stage the joint should be left alone: active movement is not encouraged and passive movements are strongly contraindicated. It is unusual to recover full movement, and one is tempted to excise the new bone in the hopes of increasing the range. The operation is rarely successful.

7 TENDON RUPTURE

A tendon may be frayed by the sharp edge of a bone fragment and rupture, apparently spontaneously some weeks later The commonest tendon to be affected in this way is the long extensor of the thumb

8 INJURY TO VESSELS

An aneurysm is a rare complication. Much more common is thrombosis of a deep vein which shows itself as an intractable oedema.

9 NERVE COMPLICATIONS

Involvement of a nerve in callus is of doubtful occurrence. The majority are instances of primary damage undiagnosed at the time of the injury

Under this heading may be placed a condition known as *Zudek's atrophy* (fig. 124), in which after a straight forward fracture there appears what seems to be an irritative lesion of the sympathetic nerves The aetiology is a guess.

The patient complains of great pain, made worse when the limb is touched or moved. The skin becomes thin and glossy the limb is cold and all joints stiffen. The radiograph shows a characteristic form of patchy atrophy

With or without treatment, recovery gradually takes place in a year or two. Physiotherapy rarely helps and often increases the pain. If it does it should be discontinued Warmth is comforting, and active movements do no harm. Nothing should be done that makes the pain worse.

10 LOSS OF FUNCTION

This is the commonest complication of a fracture. It is due to allowing the brain to lose control of the injured limb during repair It is not malingering nor is it a neurasthenic manifestation. The muscles are stiff the joints are stiff and the control of the circulation is lost. This too-frequent complication is the result of faulty treatment and is responsible for months of unnecessary invalidism.

II

Dislocations

The terms subluxation and dislocation require defining In a subluxation the joint surfaces although shifted on one another are still in contact. In a dislocation they are no longer in contact. A traumatic subluxation is usually accompanied by a fracture. It cannot be diagnosed except by a radiograph. Reduction of the fracture automatically reduces the subluxation, and vice versa.

DISLOCATION

Signs

Dislocations present three signs: (1) an abnormal contour (2) immobility of the joint, and (3) a particular attitude. With these characteristics it is strange that a dislocation is often overlooked. An X ray should be taken as a matter of course after every injury and this usually reveals the dislocation. The radiograph however may be deceptive, as with a posterior dislocation of the shoulder (fig 57).

A fracture with displacement may mimic a dislocation, but movement though painful is possible.

Treatment

Unless seen immediately after the accident a dislocation cannot be reduced until the muscles, which are in spasm, relax under anaesthesia. The anaesthetic must be deep nitrous oxide is not sufficient. Once the muscles are lax the dislocation reduces easily when a force opposite to the force that caused the dislocation is applied.

There is rarely any doubt about reduction, and reduction when it occurs is complete. There is no support for the assumption made by some bone setters that a joint may be out of place i.e. subluxated. In the absence of a fracture a joint is either dislocated or it is in its normal position.

If there is doubt about the reduction it is quickly dispelled by the patient when he comes round from the anaesthetic. After a successful reduction the joint, which before was immobile, moves freely and the relief of the patient is very evident.

There are two schools of thought about after treatment. According to one, the joint should be immobilised to allow the torn ligaments to repair According to the other free movement may be allowed at once since the muscles will

check movement before any strain falls on the ligaments. In a joint such as the shoulder where recurrence of the dislocation is not uncommon it is reasonable to hold the shoulder internally rotated for a few weeks after reduction to avoid being blamed for a recurrence, but in joints that do not redislocate immobilisation is unnecessary and the sooner the joint is allowed to move freely the *quicker it recovers*.

Complications of a dislocation

1 *Recurrence* There is nothing to prevent a joint that has once dislocated from redislocating if the patient meets with another equally severe accident. This does not often happen Sometimes however a joint that has once dislocated redislocates after a trivial injury This occurs at the shoulder at other joints it is rare.

2. *Joint stiffness* The joint remains stiff for some time if it is immobilised, but as a rule gradually loosens. Permanent stiffness follows some dislocations and not others. At the shoulder recovery is usually full, at the elbow slight limitation of movement is not uncommon.

3 *Fracture* A fracture can complicate a dislocation in two ways: Either the force that dislocates the joint also breaks the bone. The two injuries then need separate treatment; the joint is first put back into position and afterwards the fracture is treated. Or as the joint dislocates it avulses a fragment of bone into which are inserted the muscles that stabilise the joint. Reduction of the dislocation generally replaces the avulsed fragment and the fracture does not require separate treatment (fig 54).

4. *Nerve injury* This is common. The nerves are injured by being stretched. Since they are not anatomically divided suture is not necessary The interruption may however be complete physiologically in which case the nerve degenerates and recovery has to await regeneration. It may be some months before the nerve is working again.

5 *Injuries to vessels* The main artery running across the joint may be damaged. This complication is rare

6 *Injury to muscles* When a patient foresees the accident he automatically puts his muscles into action to resist the force, and the muscles tear before the joint dislocates. Whether the muscles are injured or not affects the prognosis. A shoulder recovers full movement within a few weeks when the muscles have escaped injury but if they have been injured it will be some months before full painless movement is restored

Sometimes the damage to the muscles is rendered obvious by a widespread deposition of calcium—myositis ossificans. Myositis ossificans is also a complication of a fracture and is referred to on page 59

12

Fractures of the Skull

There are three kinds.

Depressed fracture of the vault.
FISSURE FRACTURE OF THE BASE
Missile fracture.

The injury to the bone is of little moment compared with the injury to the underlying brain.

** DEPRESSED FRACTURE OF THE VAULT

This is caused by a blow from a bottle or similar instrument. Usually the scalp is split and the bone is stove in at the point of impact. When the skin is not split it may be difficult to tell whether bone has been depressed and an X ray should always be taken. Injury to the underlying brain is rare, and the patient may not lose consciousness.

Treatment

When there is a wound the scalp should be shaved around it and the wound edges separated so that the bone can be explored with a probe. Operation is not necessary if the bone has not been depressed, and the patient need not be admitted to hospital. If there is any likelihood that bone has been depressed the patient should be admitted to hospital and the wound explored in the theatre. All depressed fragments should be elevated, if necessary through a small trephine opening made close by

When there is not a wound, operation is reserved for unconscious patients and those showing focal signs of brain injury

In children the bone is indented and not fragmented (pond fracture), and operation is rarely required

** FISSURE FRACTURE OF THE BASE

This is the usual fracture that follows a head-on collision The skull is momentarily indented, tension within rises and the bursting stress on the inside of the skull causes fissure fractures running in all directions (fig 26). The fractures may extend to the vault but more commonly pass through the weak bones of the base, where the dura is firmly adherent. The dura is torn and a

Fig 26 Fracture of the skull Contrast the fracture lines with the sutures.

passage is opened between the subdural space and the exterior This is shown by a flow of cerebrospinal fluid and blood from the nose and ears. Along this passage organisms can gain access to the brain and cause a septic meningitis. Antibiotics should always be given to a patient with a head injury A fissure fracture that passes through the floor of the anterior fossa causes a subconjunctival black eye

The injury to the bone does not need treatment and should be disregarded. It is better not to syringe the nose and ears. Attention is focussed on the brain injury

INJURY TO THE BRAIN

The brain, if damaged, exhibits in succession the clinical states of concussion, irritation and confusion These, which are to be expected in most cases of head injury do not need any treatment except nursing A fourth state—compres

sion—is sometimes superimposed on these three· this requires energetic and urgent treatment.

CONCUSSION

This happens at the time of the blow and lasts some seconds to a minute or two The brain does not show any evidence of injury when examined microscopically and there is no convincing explanation of concussion. The higher centres of the brain suddenly cease to function for a short time. The patient drops to the ground as though felled, and enters into deep coma. Recovery is automatic and the patient recovers before any treatment can be given As he regains consciousness he may feel and be sick.

IRRITATION

A state of irritation follows soon after consciousness is regained. Macroscopically there may be local laceration of the surface of the brain, and microscopically oedema and small haemorrhages are scattered throughout the entire brain.

The depth of coma varies. The patient may be noisy and delirious. More often there is semi-coma, the patient appears unconscious but can be roused. When roused he is very bad tempered If conscious he lies motionless and silent on account of a severe headache. His eyes are shut and he resents their being opened The pupils, which may be difficult to see on account of the photophobia, are equal, small and active. Muscle tone is high, particularly in the flexors and the patient lies in bed curled up on his side. He responds aggressively when the skin is lightly touched with a pin. The temperature, pulse, respirations and blood pressure are normal. After lasting several hours the state of irritation passes away gradually

Treatment

The patient is disturbed as little as possible. He should be in a quiet room and in semi-darkness. If he is restive a sedative such as sodium luminal is given. There is a danger of flooding the lungs with saliva and mucus which the patient is unable to swallow and it may be advisable to raise the foot end of the bed. Solid food is of no importance for a day or two but the patient requires fluid and this may have to be given through a stomach tube. The bladder may need emptying twice a day by a catheter Lumbar puncture should be carried out after six hours and repeated if the tension of the cerebrospinal fluid remains high. In former times it was the custom to keep the patient in bed for one day for every minute of unconsciousness in the belief that this avoided post traumatic headache. It is now believed that, on the contrary early rising best avoids a neurosis.

CONFUSION

This always follows a state of irritation although it may pass unnoticed clinically The patient may not know where he is or who he is. His disposition

changes and he is apt to behave like a naughty child, and to be a nuisance in the ward. Gradually he recovers his normal mental health.

COMPRESSION

Whereas concussion, irritation and confusion are common, and accompany most fractures of the base of the skull, compression is rare. It is a complication and a dangerous one. Intracranial tension rises, partly on account of haemorrhage and partly owing to the blocking of the aqueduct leading from the third to the fourth ventricle, which interferes with the circulation of cerebrospinal fluid. The rise in tension forces the brain down through the tentorial opening and squashes the midbrain. As a result of the pressure on the midbrain and on the third nerve (which is lying alongside the midbrain) there is decerebrate rigidity a fixed dilated pupil, and a squint. If the pressure increases the medulla is pressed through the foramen magnum and the respiratory centre ceases to work.

Compression takes time to develop There may therefore be a *latent interval* between the recovery from concussion and the onset of compression during which the patient is only in stupor or semicoma. Gradually the coma deepens. Other signs of increased intracranial pressure may not be evident: headache is masked by the coma, and papilloedema is not seen for a few days. The pulse rate, however slows, and the blood pressure begins to mount. Every half hour the nurse should record the state of consciousness, the pulse rate and the blood pressure and any change should be reported at once to the doctor

Later on, signs of pressure on the midbrain become apparent: spastic hemiplegia, unilateral squint, and unilateral dilatation of the pupil. Spasticity is shown by an alteration in the tone of the muscles on the two sides. When compression sets in, the third nerve is paralysed and the pupil on one side dilates and ceases to react to light. Again the difference on the two sides is the important factor Usually the dilated pupil is on the side opposite the hemiplegia.

As soon as the signs of compression appear surgical interference must be immediate. The intracranial tension must be reduced by a decompression operation. It is difficult to know where to make the trephine holes. To be on the safe side two trephine holes should be made on both sides, one above and one below the tentorium. The one above may well be located over the middle meningeal artery although bleeding from a torn meningeal artery is responsible for the compression in only a third of the cases. Treatment of compression is a task for an expert It is sufficient for the doctor to be able to recognise the early signs and to obtain expert neurological help even if this involves despatching his patient to another centre. Contrary to belief patients with head injuries travel well.

In brief the indications for decompression are deepening coma, and prolonged unconsciousness. Decompression should be undertaken before decerebrate rigidity and a dilated pupil appear Attempting to reduce pressure

by a lumbar puncture is bad treatment; it does not decompress sufficiently and is moreover dangerous, since with the reduction of tension in the spinal canal the medulla may be sucked into the foramen magnum and the respiratory centres paralysed.

INJURIES TO CRANIAL NERVES

Fissure fractures of the skull may be accompanied by injury to cranial nerves.

The olefactory nerves are often damaged, and the damage is usually permanent.

Immediate blindness is occasionally met with. If due to haemorrhage the nerve recovers, but if the nerve has been severed recovery is not possible. Blurred vision is usually due to a temporary paralysis of accommodation. Temporary diplopia is also common. When caused by displacement of the eye from a fracture of the orbital floor the fracture is best reduced for cosmetic reasons.

The seventh and eighth nerves may be irretrievably damaged at the time of the accident. The nerves may also be compressed later by clot, and temporary deafness appears a few days after the accident. Later still, the nerves may be compressed by callus, recovery can then sometimes be helped by operation

*** MISSILE FRACTURE

A high-velocity bullet passes through the skull. The missile inflicts a minimal amount of damage to the brain, and on account of its heat is sterile. The wounds of entry and exit are small and are best left alone

A fragment of shell of low velocity often remains inside the skull. The missile carries organisms with it. A wound toilet should be done and pulped brain removed, but undamaged brain substance should not be disturbed. A foreign body that comes to hand is removed but no attempt should be made to search for pieces of shell.

13

Injuries of the Face

Dislocation of the mandible
Fracture of the horizontal ramus of the mandible
Fracture of the ascending ramus of the mandible
Fracture of the neck of the condyle
Fracture of the nasal bone
Fracture of the malar bone
Fracture of the maxilla

Fractures of the face bones are caused by direct blows. Black eyes, a bleeding nose and swollen eyelids may occur without a fracture but they should be taken to signify the presence of a fracture until proved otherwise.

An orderly examination usually reveals which bone, if any has been broken. Six points are noted. Are the eyes level? Is the nose flattened? Is the face flattened? Does the zygoma feel irregular? Does the infraorbital margin feel irregular? And do the teeth meet properly?

Treatment is centred on three objects: to maintain an airway to restore symmetry to the face, and to make the teeth meet properly These are respectively best looked after by an anaesthetist, a plastic surgeon, and a dentist rather than by an orthopaedic surgeon. The general practitioner and casualty officer are wise to off load all fractures of the face.

• DISLOCATION OF THE MANDIBLE

The jaw is apt to dislocate spontaneously during yawning and hearty laughing The condyle slips forwards in front of the articular eminence.

The signs are striking The mouth is half-open, and will neither open more nor close and saliva dribbles from the mouth on account of the difficulty of swallowing

Replacement may be possible without an anaesthetic, but it is easier with one. The two thumbs, well padded, are introduced into the mouth and made to press downwards on the teeth as far back as possible. No after treatment is necessary except that the patient should avoid opening his mouth too wide.

•• FRACTURE OF THE HORIZONTAL RAMUS OF THE MANDIBLE

This is a common injury and is caused by a blow on the chin. The line of fracture is vertical It may be in the midline or there may be two fractures

about an inch either side of the midline. The mucoperiosteum on the oral surface of the bone is torn.

Local tenderness, inability to close the teeth and pain on attempting to move the lower jaw suggest the diagnosis.

Treatment

This depends on whether the fractures are bilateral single without displacement, or single with displacement.

Bilateral fractures of the mandible allow the tongue to fall back and the airway becomes obstructed. As with all fractures of the jaw the first consideration is to secure a clear airway The tongue should be pulled forwards until an anaesthetist's nasopharyngeal tube can be passed. The patient is then passed over to the dentist. His job is to fix the fragments so that the bite is afterwards normal. This he does by wiring together the teeth. Any loose tooth in the path of the fracture is removed. As there is a communication between the bone and the septic oral cavity the mouth should be kept clean and antibiotics given.

Single fractures without displacement The criterion of displacement is the bite. If the teeth appose there is not any displacement to worry about. Fractures of this sort are treated simply by holding the mandible in contact with the maxilla by means of a fourtailed bandage or a barrel bandage (fig 27). Food requiring mastication is withheld for some weeks.

Single fractures with displacement. These require reduction and splintage by a dentist.

** FRACTURE OF THE MANDIBLE BEHIND THE TEETH

This is caused by a blow on the side of the jaw The ascending ramus is broken. The position and direction of the fracture line is variable. The fracture is behind the teeth and occlusion is not often a problem. And since the buccal mucous membrane is not torn, bone sepsis need not be feared.

Treatment

A fourtailed bandage or a barrel bandage is worn for three weeks. Internal fixation by metal or dental wiring may be necessary if one fragment tilts on the other

** FRACTURE OF THE NECK OF THE CONDYLE

This is caused by a blow on the side of the face. There is localised tenderness and, although the bite is normal, the patient opens his mouth to one side. The fracture is only important because it may be overlooked.

* FRACTURE OF THE NASAL BONE

This is a boxing hazard, it also follows a fall from a horse. One side of the nose is driven in and the septum is displaced towards the other side; or the blow is delivered end-on and both nasal bones are fractured and the nose is squashed.

Fig 27 Barrel bandage for the jaw

Displacement may be hidden by swelling After a blow on the nose a fracture should always be suspected

Reduction is easy and must be done to avoid an ugly deformity and to preserve a clear nasal passage. Artery forceps are introduced through both nostrils and any depressed fragment elevated. The side-blow fracture is stable after reduction and no splintage is necessary the end-on fracture is unstable, and the nasal bones have to be kept in position after reduction. This is usually done by sutures passing through the skin The nostrils should not be plugged, except to check haemorrhage, since this increases the risk of sepsis.

Reduction ought not to be undertaken in a lighthearted fashion Full intra tracheal anaesthesia is insisted on.

** FRACTURE OF THE MALAR BONE

This is caused by a direct blow which breaks the zygoma and staves in the central fragment.

Displacement is concealed by the swelling Local tenderness makes one suspect a fracture This is confirmed by a radiograph, which may not show the fracture lines but always shows an opaque antrum.

There is anaesthesia or hyperaesthesia of the cheek from injury to the intra orbital nerve and this may persist for some months.

Treatment

Open reduction is necessary for cosmetic reasons. A small incision is made in the temporal region of the scalp which is previously shaved. Through this a bone spike is pushed down deep to the temporal fascia and under the zygoma, and the zygoma then levered forwards. The reduction is stable and splintage is not required.

*** FRACTURE OF THE MAXILLA

The maxilla is smashed in from the front and pushed backwards. The fracture line is horizontal and at varying levels. A fracture of the maxilla is often accom panied by a fracture of the zygoma and mandible.

In spite of the gravity of the injury shock is often mild. Bilateral orbital haematomata and subconjunctival haemorrhages and puffy eyelids make one suspect a fracture of the maxilla. The eyes may not be on the same level. There is irregularity of one or both infraorbital margins. The teeth do not meet. Blood and cerebrospinal fluid flow from the nose. Saliva pours from the mouth if the mandible is also broken and there may be respiratory distress

Treatment

The immediate task is to ensure a clear airway The tongue is pulled forwards, and as soon as possible a nasopharyngeal tube is passed.

For definitive treatment the patient is handed over to the plastic surgeon. Reduction should be done as soon as possible. The maxilla is gripped in bone-holding forceps and pulled forwards into its proper position. The large frag ment may need mobilising first. Depressed fractures of the malar and nasal bones may also need elevating Lacerations of the skin are then sewn up And finally the maxilla is held in position by a dental cap cemented to the upper teeth, which is fixed to a plaster head cap It is no job for an amateur

14

Fractured Ribs

A fractured rib is a common injury and is often poorly treated. The fractures unite of their own accord and the bone does not require treatment. Neverthe less a fractured rib is important for many reasons; it is painful, the pain makes sleeping difficult, the pain prevents an early return to work and there is danger from inefficient respiration and intrathoracic injury

The principles of treatment are briefly (1) To relieve pain. (2) To make breathing easy and effective. And (3) to diagnose and treat intrathoracic com plications.

Inefficient respiration

Respiration may be rendered inefficient by pain, by collapse of the thoracic cage, and by the accumulation of air fluid or blood inside the pleural cavity

Pain On account of pain breathing is shallow and rapid, and the patient is afraid to take a deep breath. Shallow breathing is fatiguing to the muscles and wearing to the patient; and pain should be abolished by a liberal supply of morphia and by the injection of a local anaesthetic into the haematoma around the broken rib As soon as the anaesthetic takes effect the patient is able to breathe normally and even when the analgesic effect wears off he is still able to breathe freely and without much discomfort.

Collapse of part of the thoracic cage A single fracture does not destroy the rigidity of the thoracic cage, neither do single fractures in several ribs, but a double fracture in one or more ribs causes collapse of part of the thoracic cage. If a piece of the thoracic cage is floating, i e. cut off from the rest of the cage, breathing becomes paradoxical. the isolated part of the chest wall is drawn in when the patient inspires and blown out when he expires. Paradoxical respira tion of sudden onset has a devastating effect on the efficiency of respiration. The relief afforded by the application of a plaster-of paris slab over the hole in the cage is dramatic.

When the greater part of the thoracic cage loses its rigidity (which is un common) artificial respiration becomes necessary

Intrathoracic complications

These are diagnosed by aspirating the pleural cavity and by X raying the chest.

Pneumothorax When the lung is damaged air escapes into the pleural cavity and, the pleura under the broken rib being torn, the air in the pleural cavity

escapes into the subcutaneous tissues and reveals itself as surgical emphysema—a diffuse swelling over the chest wall and neck which crepitates.

Surgical emphysema is a signpost to the presence of pneumothorax. A pneumothorax is, however revealed most clearly by a radiograph.

A closed pneumothorax is of little consequence and needs no treatment. It does not incommode the heart or interfere much with respiration. The air is rapidly absorbed and the lung underneath expands

However with an open fracture or when the bronchus is torn the opening through which the air passes into the pleural cavity may be valvular and then a *tension pneumothorax* develops. This is serious. The action of the heart is impeded and vital capacity is much diminished. The patient is in great pain is cyanotic, and dyspnoeic. Treatment is needed urgently A hypodermic needle should be inserted into the second interspace in front, four inches from the midline or into the sixth space in the midaxillary line. A nicked rubber finger stall is fitted over the hilt of the needle to act as a valve.

Haemothorax A small amount of bloody effusion is common, and does not attract attention. Quite a lot of blood can collect in the pleural cavity without giving physical signs. On the day after the accident the chest should be aspirated if a haemothorax is suspected, and the needle connected to a tube leading down under water Exercises are started and the patient is encouraged to re expand his lung and obliterate the dead space. He is also encouraged to cough in order to remove impacted mucus from the smaller bronchioles. Penicillin is given as a preventative against lung infection. It is important to get the patient to re-expand his lung before the blood clot on the surface of the lung has been converted into inelastic scar

Traumatic asphyxia. This is an unusual accompaniment of a crush injury A violet black discoloration covers the skin of the face, neck and chest as far down as the nipples. The colour does not appear where there is external support; and the braces collar and brim of the hat may be outlined on the patient s gaudy skin. The colour is due not to actual haemorrhage but to dilatation of the skin venules, for it disappears without exhibiting the colour changes of a bruise, sometimes in a few hours. Lozenge-shaped subconjunctival haemorrhages occupy the exposed portions of the conjunctivae. The picture is alarming and the patient appears in extremis. But it is not serious and treatment is not needed. It does, however indicate that compression has been severe.

CLASSIFICATION OF FRACTURES OF THE RIBS

Closed Fractures	Traumatic:	Impact fracture
		Crush injury
	Spontaneous.	Cough fracture
		Secondary-deposit fracture
		Idiopathic fracture
Open Fractures	Stab wounds	
	Gunshot wounds	

Fig. 28. Fractured ribs.

Fig. 29. Spontaneous fracture of first rib. Probably old fracture on the other side.

CLOSED FRACTURES OF THE RIBS

• IMPACT FRACTURE OF A RIB

A direct fracture of a single rib from a blow is a common injury for example a person stumbles and hits his chest against the furniture. The break is anywhere in any rib (fig 28) Usually the fracture is single and the ends of the bone are not driven into the lung and therefore intrathoracic complications are rare. Severe internal haemorrhage occasionally comes from a torn intercostal artery

Diagnosis

There is a history of a blow and the patient complains of pain on breathing The patient can put his finger unerringly onto a localised tender spot. The fracture may not be visible in a radiograph and the diagnosis rests on the history and the one physical sign.

Treatment

The bone does not need treatment. The intercostal muscles prevent displacement so that reduction is not necessary and they also hold the fragments so that splintage is not necessary The classical method of treatment is to strap the chest in expiration This method should be given up Strapping does not relieve pain, it irritates the skin and is painful to remove, it impedes normal breathing and it prevents clinical examination of the chest and renders aspiration difficult.

It is important to get the patient to expand his chest to the full while the fracture is mending in order to prevent an annoying neuralgia which is sometimes a sequel when the chest wall has been immobilised, and also in order to re-expand the lung if there has been a haemothorax or pneumothorax. What stops the patient from breathing deeply is pain. And the sole reason for treating a fractured rib is to relieve pain and so allow normal respiration.

An injection of morphia should be given and a long-lasting local anaesthetic injected into the haematoma around the fractured rib The localised tender area indicates where to insert the needle

•• CRUSH INJURIES

The thoracic cage is compressed. Either the chest is squashed between say the rear end of a truck and a wall, or the person is run over

More than one rib is broken, and each rib is broken in more than one place. The exact position of the fractures is immaterial. What matters is that a piece of the thoracic cage becomes isolated and causes paradoxical respiration. The floating portion of the cage is sucked in when the person inspires, and is blown out when he expires Paradoxical respiration in its acute stage can cause death. The diagnosis presents no problem because paradoxical respiration of any importance is obvious on inspection.

It is well to remember that ribs may be broken in crush injuries of the

abdomen. Raised intra-abdominal pressure can burst the lower ribs. The lesion is not uncommon in children. No immediate special treatment is required, but the injury is important because it is frequently associated with a rupture of the diaphragm, which is followed by a diaphragmatic hernia.

Immediate treatment

If paradoxical respiration is not gross it is sufficient to support the affected area of the chest cage by a thin slab of plaster-of paris, which is bandaged over the floating area. Morphia is given in liberal amounts. Often there are other serious injuries demanding attention.

If the patient is acutely distressed from paradoxical respiration he must be put forthwith into a Drinker's respirator Alternatively a tracheotomy is done and a positive-pressure respirator connected to the tracheotomy opening

On the day after a crush injury the chest is X rayed for pleural complications; any pleural collection should be removed by aspiration.

• COUGH FRACTURES

These are common. The fracture is produced when a person tries to suppress an irritating cough. They are commonest in the axillary parts of the lower ribs.

The patient comes up complaining of pain on taking a deep breath and is thought to be suffering from pleurisy However a localised tender spot can always be found over the fracture and often a lump can be felt. The diagnosis is confirmed by a radiograph.

Treatment

When the cause of the cough is known, for example pulmonary tuberculosis, medicines are given to damp down the cough. When there is no obvious cause for the cough the patient should be investigated fully to establish whether there is any disease of the bronchus.

The fractures (there may be more than one) do not need treatment

• *FRACTURES DUE TO SECONDARY DEPOSITS*

There may be a single fracture through a single palpable lump or there may be several fractures, only revealed by radiography The fractures are often symptomless.

• IDIOPATHIC SPONTANEOUS FRACTURE

Spontaneous fracture of the first rib and less commonly of the second rib is not uncommon. The patient is a young man and the rib breaks at the scalene tubercle (fig 29). There may be slight pain and local tenderness, but often the fracture passes unnoticed and is only discovered incidentally in a radiograph taken after the fracture has healed. Treatment is not required. Often the radiograph shows a similar fracture on both sides. The fractures unite with bone without treatment and without complications.

** STAB WOUNDS OF THE CHEST WALL

Penetrating wounds caused by stabbing quickly seal themselves. Symptoms are few and the signs those of a haemothorax. Often the ribs escape damage.

Treatment

A penetrating wound should be treated as a closed injury Antibiotics are given to forestall infection and the pleural cavity is kept empty by repeated aspirations. Every endeavour should be made to re-expand the lung before it becomes anchored by the organising blood clot on its surface.

It should be borne in mind that the abdomen may also have been penetrated

*** OPEN FRACTURES OF THE RIBS

Open wounds are not often seen except in times of war They are always serious. Vital capacity is much diminished because one lung is collapsed and the expansion of the other restricted. Moreover on account of pendulum breathing, half the air taken into the working lung is de-oxygenated. The action of the heart is upset by the side-to-side movement of the mediastinum (mediastinal flutter) and pressure on the great veins interferes with the filling of the heart. The patient is in severe shock, he is dyspnoeic and cyanotic, the pulse rate is rapid and the blood pressure low

Immediate treatment

Immediate treatment is required. As a first aid measure the wound is covered with a large and stout dressing which is firmly strapped onto the chest. Morphia is given and an oxygen mask is fitted if available. As the patient is on his way to hospital the foot-end of the stretcher is raised so as to prevent the flooding of the lung with blood and sputum. The patient travels on his wounded side.

As soon as the patient reaches hospital a blood transfusion is set up The patient is then taken to the theatre for a wound-toilet operation. The first-aid dressing on the chest wall should not be disturbed until some sort of controlled respiration is available. At the operation torn intercostal vessels are tied, fragments of cartilage and rib are removed and devitalised muscle excised. The pleural cavity is emptied of clot and bloody fluid by a sucker under direct vision. The hole in the lung seals itself as the lung collapses and bleeding from the lung has automatically ceased by the time of the operation. Foreign bodies that come to hand are removed but others are not searched for Any portion of lung completely pulped is better excised. Antibiotics are left in the pleural cavity which is drained by negative pressure. Before the wound is closed the anaesthetist re-expands the lung and at the end of the operation he sucks out the bronchi through an intratracheal tube. The skin of the chest wall is closed if possible, and the thoracic cage should be supported by a plaster-of-paris slab if it has been necessary to excise fragments of several ribs.

Back in the ward the patient is given morphia, and nursed in the position he finds most comfortable. On the next day he is made to cough and to breathe deeply and the pleural cavity is aspirated if it has not been drained and penicillin instilled into it. In times of war the patient should be kept for a few days before being sent down the line.

15

Injuries of the Spine

With a fracture of the spine damage is not confined to the skeleton, the back muscles are torn, and the cord and nerve roots may be divided A fracture of the spine is therefore a triple injury Bone, muscle and nerve each require different and often antagonistic treatment.

INJURY TO THE SKELETON

The extent of the damage is only revealed by radiographs. Three things are looked for (1) a wedged shaped vertebra, (2) shift of one vertebral body on another and (3) displacement of articular facets. The first two are easy to see; the third will not be seen except in a very clear radiograph.

From the skeletal point of view displacement is of no importance. Neither a crushed body nor a subluxation nor wrongly positioned facets interferes afterwards with function.

The bony injury therefore does not call for treatment on its own account. But, when nerve roots have been injured it is desirable to reduce any displacement and to hold the spine immobile to improve the chances of successful regeneration.

INJURY TO THE MUSCLES

A force sufficient to cause a fracture or a fracture-subluxation of the spine also lacerates the muscles of the back. The injury inflicted on the muscles is of no account, but widespread scarring is inevitable from organisation of scattered small clots. Scarring impedes the action of the muscles, and the patient afterwards suffers from residual backache unless he has kept his muscles moving while the scar was forming

Therefore, for the good of the muscles, a patient with a broken back should not be immobilised, but on the contrary should exercise his back from the start in spite of discomfort.

INJURY TO NERVES

Since the nerve roots run alongside the cord for one or more segments before leaving the spinal canal, a force that injures the cord is likely to injure also some nerve roots. In fact, damage to the cord' in relation to a fracture of the spine always means cord *and* nerve root damage. Division of the cord is final,

no regeneration is possible. But divided nerve roots can regenerate, and the chances of successful regeneration are improved by reduction and immobilisation of the fracture.

Damage to the cord may be transitory or permanent After any fracture of the spine conduction up and down the cord may be temporarily suspended. The pathology is not understood. Although no nerve cells are killed and no nerve columns are damaged, the cord behaves as though it had been cut across. The cord begins to resume conducting within a few hours of the accident. The condition is called spinal concussion.

In the thoracic region of the spine, permanent damage to the cord and nerve roots only occurs with a fracture-subluxation, although the subluxation may only be momentary and the radiographs may not show a shift in either view In the cervical region of the spine permanent damage to the cord may occur with hyperextension injuries without either a fracture or a subluxation.

The damage to the cord and nerve roots is always done at the time of the accident, and there is little to be said for carrying an injured man face-downwards on his way to hospital in case a displaced fragment of bone may be pressing on the cord. It is, however common prudence not to carry the patient doubled up

At the common level (between the 11th thoracic and the 1st lumbar) the cord is nearing its end Below the level of the first lumbar vertebra the supposed cord damage is all sustained by the nerves of the cauda equina.

In spite of the term permanent, some recovery is possible in nerve-root injuries. Permanent disability in any case is great· it is a matter of whether the patient will be completely bed ridden or will be able to get about with the aid of caliper splints.

Only time will tell whether the nerve damage is transitory or permanent and partial, or permanent and complete. In all three cases there may at first be a flaccid paralysis of all the leg muscles and anaesthesia from the groins downwards. A band of hyperaesthesia helps to locate the level of the lesion. The patient cannot pass water and unless the bladder is artificially emptied retention gives way to dribbling incontinence.

With a temporary impairment of conduction sensation returns in a few hours, and at the end of 24 hours one can predict *fairly accurately the amount* of irreparable damage.

Treatment

Treatment of the nerves takes precedence over and controls, the treatment of the fracture. Treatment has two aims: to assist regeneration, and to alleviate paraplegia.

Assisting regeneration. Damage to the cord is irreparable. Nerve roots, however can regenerate, and regeneration is made easier if the nerve ends are in apposition. It is desirable therefore to reduce any bone displacement or subluxation, and it is desirable also to immobilise the spine in order to prevent

newly joined nerve ends from being torn apart. Reduction is more easily and more accurately accomplished at open operation than by a blind manipulation. The decision to operate is made within twenty four hours, as soon as it is clear that the neurological signs are not accounted for by temporary spinal concussion. At the operation, after the spinous processes and the laminae have been exposed, it is simple to immobilise by internal fixation. Plates on either side of the spinous processes are bolted together the bolts passing through the processes.

Alleviating the paraplegia. This consists of avoiding bedsores, preventing urinary infection preventing contractures and getting the patient ambulant.

1 Avoiding bedsores. The skin is especially vulnerable in the first few days. Thereafter it acquires a tolerance to pressure. A slough the size of a shilling can appear almost overnight, and grow to the size of a saucer within a week.

Treatment is in the hands of the nursing staff. The patient should lie on a rubber mattress, his position must be changed every two hours day and night, and his skin must be kept dry and clean and not bathed in urine and faeces. It is painful for a man with a broken back to be moved and, moreover movement might increase the damage already done to the cord and nerve roots. Internal fixation solves this difficulty for with the spinous processes fixed, the patient can be safely and painlessly rolled over on to his side.

2. Preventing urinary infection. Formerly 50 per cent of traumatic paraplegics died of urinary infection within two months of the accident. Better treatment has brought the figures down to negligible proportions. Antibiotics are given as a routine. The patient is encouraged to drink so as to flush the urinary tract; and, above all, urine is not allowed to stagnate in the bladder An automatic bladder will not be acquired for six weeks. Until then the bladder must be kept empty by an indwelling urethral catheter or by intermittent catheterisation.

3 Preventing contractures. In the early flaccid stage an equinus develops rapidly later flexion contractures appear at the hip knee and ankle. A physiotherapist should be employed from the start to move every day all the joints through a full range. Splints may be required to prevent flexion deformities at the knee and ankle.

4. Rehabilitation. Patients with cauda-equina lesions can be made ambulant with the help of crutches and knee-straight calipers. Patients with high cord lesions sometimes remain bed ridden.

Injuries to the spine are conveniently divided into five groups:

- Fractures of the thoracic and lumbar vertebrae.
- Injuries of the cervical vertebrae
- Injuries of the atlas and axis.
- Fracture of the processes.
- Pathological fractures.

FRACTURES OF THE THORACIC AND LUMBAR VERTEBRAE

Only two fractures of the bodies are common, compression fracture and fracture-subluxation.

COMPRESSION FRACTURE OF THE SPINE

This is caused by hyperflexion. A person falls in a sitting position, a rider is thrown from his horse or a miner is pinned under a falling roof. There are two main types, the stable fracture and the unstable fracture.

* THE STABLE FRACTURE (INTERSPINOUS LIGAMENT INTACT)

The spine is not at any moment unstable, there is never at any time any diminution in the lumen of the spinal canal, and the cord and nerve roots are not damaged.

The lateral radiograph shows that the upper border of a vertebral body has been crushed, and that in consequence the body is wedge shaped instead of rectangular (figs. 30a, 31).

Treatment

The fracture should be disregarded and the patient handed over to a physiotherapist who makes him move his back in all directions. He should be touching his toes in ten days. Directly he can do this he needs no further treatment (fig. 30b).

The treatment advocated above is not orthodox. The orthodox treatment is to reduce, i.e. to hyperextend the spine until the vertebral body is again rectangular, and then to hold the reduction by a plaster jacket. There are many reasons for recommending activity in place of fixation. (1) Although reduction is possible in the freely moving lumbar spine by hyperextension of the back, in the thoracic region of the spine where extension is prevented by the rigid chest wall reduction cannot be obtained. (2) To hold a reduction in the lumbar region the back must be plastered in full extension—not an easy thing to do. Even when reduction has been obtained the displacement usually recurs. (3) Perfect function is compatible with poor reduction. A wedge-shaped body does not cause pain; for instance, a patient with a healed tuberculosis of the spine does not complain of his back. (4) One of three miners who break their back returns to the coal face. Of the miners who return to the coal face those not treated in plaster outnumber those treated in plaster by two to one.

** THE UNSTABLE FRACTURE (INTERSPINOUS LIGAMENT TORN)

If the interspinous ligament gives way the spine continues to flex, and the articular facets slide on one another and separate. The spinal column is then unstable and the contents of the spinal canal are exposed to injury. The dislocation of the intervertebral joints is only temporary, and as the spine

Fig 30 a (*left*) Stable fracture of the body of a vertebra, b (*right*) patient bending down touching his toes two weeks later

Fig 31 Stable crush fracture of the body

FIG. 32. Unstable fracture of the thoracic spine: *a* (*left*) forward shift of the body; *b* (*right*), lateral shift of the body

straightens the facets regain contact; but the upper facets may return in front of the lower facets instead of behind It is important to know that this has happened because the spine remains unstable, and the patient cannot be allowed up with safety to the cord. The condition is called *dislocation with locked facets*

It is rare that a radiograph of a fractured spine is clear enough to show locked facets. This is presumed to be the state of affairs when two lateral radiographs, one taken with the patient prone and the other with him supine, show the same degree of kyphos. Rupture of the interspinous ligament can however be recognized on palpation, and if a gap is felt, it is as well to presume that the spine is unstable. The spine must be made stable in order that the patient can get up when there is not any cord damage, and when there is cord damage in order that he can be nursed properly It may be possible by flexing the back and then extending it to restore the facets to their original position, but it is simpler to excise the facet which faces one at the operation and then to stabilize in the routine way by bolting together the spinous processes.

*** FRACTURE SUBLUXATION OF THE SPINE

The patients are horsemen, miners or motorcyclists. To the ordinary flexion force is added rotation or a shearing force. Either the neural arch is fractured or the intervertebral joints are dislocated, and the disc with a slice of the lower body is carried forward with the upper body The radiograph shows a lateral or an antero-posterior shift (figs. 32a, 32b). The rotation element is disclosed by fractures of the transverse processes.

Damage to the cord and nerve roots is usual

Treatment

It is best to consider the fracture unstable whenever the radiographs show a shift. Fixation is therefore required to get the patient up (figs. 33a, 33b) or to treat the paraplegia.

The treatment of a fracture of the thoracic and lumbar bodies may be summed up thus:

If a gap can be felt where the interspinous ligament should be, or if the radiograph shows a shift, the spine should be operated on and made stable.

If there is no clinical gap and no shift in the radiograph early ambulation without any support is the best treatment.

INJURIES OF THE CERVICAL VERTEBRAE

Excluding the atlas and axis which have their own individual injuries, the cervical vertebrae may be damaged by three forces. flexion, rotation, and hyperextension.

Secondary carcinomatous deposits are common in the cervical vertebrae and often pass unnoticed until the body collapses.

** FLEXION INJURY OF THE CERVICAL SPINE

The accident is commonly a fall from a horse or a dive into a shallow bath. The site of the injury is about the fifth vertebra. Cord damage may be absent, partial or lethal

The patient often can walk, and he does not have to support his head. Movements of the neck are limited by pain but he can nod and rotate.

X-ray

Only the lateral is of value. A fracture is hard to see. The radiograph shows either nothing abnormal or a forward shift with flexion and a depression of the upper border of the vertebra below (figs. 34, 35).

Cord injury

When the cord is severed at the 4th cervical level the patient dies from paralysis of the respiratory muscles. Characteristic attitudes enable other levels to be identified. With a lesion at the 5th cervical level the arms are held to the side and there is paralysis from the arms downwards. With a lesion between the 5th and 6th the patient lies with his shoulders abducted and externally rotated and there is paralysis from the arms downwards except for the deltoids. Below the 6th cervical the shoulders are abducted but the hands lie on the chest.

Treatment

Depending on the circumstances treatment consists of no reduction and no splintage, or splintage only or reduction followed by splintage.

No reduction and no splintage When the radiograph shows no displacement and when there has not been any interference with conduction in the cord, not even at the time of the accident, the skeletal injury is ignored and the patient is encouraged to move his neck.

Splintage only When the radiograph is negative but there is or has been evidence of interference with conduction in the cord, it is wise to assume that there was a temporary subluxation during the excessive flexion and that subluxation might recur with vigorous flexion of the neck

With a history of temporary paralysis at the time of the accident the neck should be X-rayed in flexion. This may reveal a partial subluxation. If so flexion of the neck should be prevented for three months by a collar made of rubber and fashioned like a ruff

Reduction followed by splintage When the radiograph shows a shift displacement should be reduced by skeletal traction (fig 36a) Under local anaesthesia a skull-caliper is inserted into the outer table of the skull through trephine holes one and a half inches above each external auditory meatus. A pull of twenty pounds is applied for half an hour The neck is then extended and a lateral X ray taken while the pull is still on. If this shows the spine straight and the articular facets in their normal relationship (not transposed) the weight is reduced.

Fig 33 *a* (*left*), Unstable fracture of the thoracic spine patient allowed up *b* (*right*), six months later

Fig 34. Stable fracture of the cervical spine.

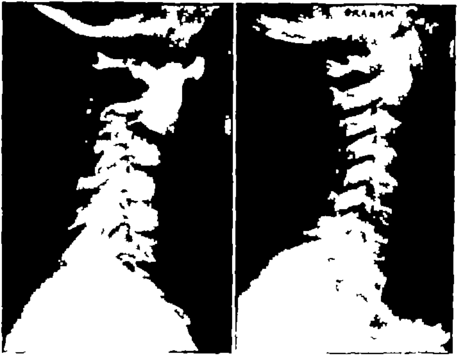


Fig 35 Unstable fracture of the cervical spine. Subluxation reduced. Interval, six weeks.

After reduction when there has not been any damage to the cord the neck is put into plaster in extension as soon as the patient can sit up in comfort. The plaster is retained for three months. The subluxation tends to recur (fig 36b) if the plaster is inefficient and allows the head to bend forwards. When there is cord damage the cervical spine should be stabilised by plating the spinous processes.

A fracture-subluxation of the cervical spine is often overlooked As a rule the subluxation does not progress and the patient is only seen because his neck has not recovered quickly Sometimes the subluxation increases until the patient has a complete paraplegia. To avoid an occasional catastrophe like this a subluxation should be reduced if possible and held reduced in plaster

• ROTATION INJURY OF THE CERVICAL SPINE

After the removal of tonsils or after a dental extraction a patient may wake up from the anaesthetic with a torticollis. Two explanations are given for this. One, that the lesion is a unilateral rotatory dislocation of one intervertebral joint, the lower articular process riding forwards in front of the upper articular process of the vertebra below The other that the lesion is a displacement of an intervertebral disc. The radiograph is not conclusive. Conduction in the cord is not interfered with.

Treatment

Head traction by means of a halter with a pull of 6 lb and the head end of the bed raised six inches, often cures overnight. If this fails manipulation under anaesthesia may be tried. Left alone the patient slowly recovers neck movements, and in view of the vulnerability of the cervical cord it is probably wise to await a natural cure.

** HYPEREXTENSION INJURY OF THE CERVICAL SPINE

This injury is limited to adults, and the usual history is a fall from a horse with the neck extended A clue to the nature of the injury is shown by bruising or grazing of the face

The patient has an uncomfortable neck but the attitude of the neck is normal and movement is possible though painful. The radiograph shows no abnormality except a narrowing of the fifth-sixth intervertebral space, with lipping of the edges of the adjacent bodies. Most people over fifty exhibit this evidence of wear-and tear Yet in spite of the negative radiograph and the paucity of the neck signs, there may be a severe damage to the cord. The damage ranges from faulty position sense and blunted tactile discrimination, caused by loss of conduction in the posterior columns, to paralysis of both arms and legs.

Post-mortem confirms that there is not any bony injury The anterior longitudinal ligament is often ruptured. The cord is torn or is necrotic, but there is nothing to indicate why It seems probable that in the position of hyperextension the cord is pressed on by the ligamentum subflava or by osteophytes (which are always present)

Treatment

There being no skeletal injury treatment for the bone is not required. The paraplegia is treated secundum artem. No harm comes of letting the patient walk about without any support to his neck.

INJURIES OF THE ATLAS AND AXIS

Although none is common three merit description. fracture of the atlas, fracture of the odontoid process, and spontaneous atlanto-axial subluxation

** FRACTURE OF THE ATLAS

This follows a blow on the top of the head.

The anterior and posterior arches may both break in two places. The spine is then unstable; the cord is cut across and the patient dies before reaching hospital. This type of fracture is not therefore a clinical problem. Usually the anterior arch remains intact and the posterior arch breaks on both sides. The fragments are held in place by the transverse ligament. The cord is not damaged.

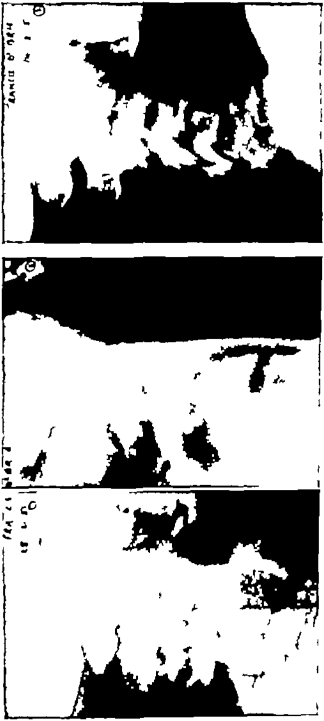


FIG. 36. *a* (*left*), Unstable fracture of the cervical spine showing the effect of head traction, *b* (*right*), two months later recurrence of the subluxation.

The patient complains of occipital headache. He supports his head in his cupped hands and is unable to nod when asked to do so The radiographs are difficult to read, and are not to be relied on in making a diagnosis

Treatment

Reduction is not needed. The patient is kept recumbent on his back until he can sit in comfort. He is then fitted with a plaster-of paris collar which he wears for three months. Occipital neuralgia is occasionally troublesome and may make the wearing of a collar almost unbearable.

FRACTURE OF THE ODONTOID

This follows a blow on the top of the flexed head a common history is diving into a shallow bath.

The odontoid process breaks transversely through its base, and the head atlas and the odontoid process shift forwards on the body of the axis

If the cord is cut across death follows immediately Often it escapes damage entirely it is a matter of all or none. Unlike other fractures of the spine the cord remains in danger and sudden death may occur some time after the accident.

The patient complains of headache and a painful neck. He holds his head erect without support, but is unable to rotate in either direction.

In a lateral radiograph it may be possible to see that the odontoid is forward on the body of the axis. An antero-posterior picture taken through the wide-open mouth shows the fracture and also shows asymmetry of the joint space between the atlas and the axis

Treatment

Extension of the neck reduces any forward shift. For three weeks the patient is kept recumbent on his back with a small pillow under the neck to extend the head. After this time the patient is got up and wears a plaster-of-paris collar for three months.

SPONTANEOUS ATLANTO AXIAL SUBLUXATION

After an acute respiratory infection, especially in children, the atlanto-axial joint may subluxate spontaneously The condition is rare. The atlas becomes decalcified owing perhaps to hyperaemia, and the bone is no longer a secure anchor for the transverse ligament. Movements of the head avulse the ligament.

A child suddenly develops a torticollis and refuses to move its neck. The cord is not often damaged in children but may be in adults.

An X ray taken through the open mouth shows asymmetry of the atlanto-axial joints and that the odontoid is no longer central.

Fig 37 Fractured transverse processes.

Treatment

When there is no cord lesion, a plaster-of paris collar is worn for three weeks or until the child moves its neck freely When there is evidence of pressure on the cord skeletal traction is applied to the head for three weeks before the plaster is put on.

FRACTURES OF THE PROCESSES

• FRACTURE OF THE TRANSVERSE PROCESSES

This injury is confined to the lumbar region. It is caused by direct violence or more commonly by sudden muscular exertion. The transverse process frac tures across its middle. Usually more than one is broken. The radiograph shows a well-defined gap between the broken ends (fig 37).

This should be treated as a soft part injury and the damage to the bone disregarded. The patient is encouraged to get out of bed, and exercises are started at once. Repair by fibrous tissue is in any case usual and immobilising the back prolongs the period of disability by creating intramuscular adhesions.

• FRACTURE OF THE SPINOUS PROCESS

This is less common than a fracture of the transverse process, and is least un common in the cervical region. The patient is perhaps a labourer engaging in shovelling clay The clay adheres to the shovel as the labourer is pitching, and the unexpected check exerts a force opposed to the neck muscles. The patient hears a snap and is unable to continue working A radiograph shows a fracture near the base of the spinous process (fig 38).

The fracture should be disregarded and the injury treated by active exercises.

•• PATHOLOGICAL FRACTURES OF THE SPINE

These are common. The body of a vertebra is squashed either on account of general rarefaction of the bones from osteoporosis or Paget s disease or on account of a secondary deposit.

Pathological fractures present in two ways. Usually an elderly woman suddenly feels pain in her back after a trivial injury Occasionally an insidious onset of paraplegia calls for an X ray of the spine.

The lateral radiograph may show a wedge-shaped body with intact upper and lower borders. In the thoracic and lumbar regions there is no shift, but a forward subluxation is not uncommon in the cervical spine. In the antero-posterior radiograph the body is flattened from above downwards and may be expanded from side to side. Or the lateral radiograph may show an ordinary compression fracture with the upper border of the body depressed and the lower border normal.

It is sometimes difficult to distinguish between a fracture caused by osteoporosis and a fracture due to the collapse of a body filled with a secondary deposit. When more than one body is wedged osteoporosis is more likely. Osteoporosis can be ruled out if in the lateral radiograph the other bodies are rectangular. When the bones are soft the intervertebral discs bulge into the bodies to make them biconcave.

Treatment

When there is no paraplegia the patient is allowed to remain in bed without treatment until the back is comfortable. Usually the fracture heals and the patient gets about again in comfort. Radiotherapy and endocrine therapy are given to check the growth and to increase the density of the bones.

When there is evidence of pressure on the cord the spine should be stabilised by bolting the spinous processes together as for an unstable traumatic fracture. In the cervical spine any subluxation is first reduced by skull traction.

Fig. 38. Fracture of the spinous process. Clay-shoveller's fracture.

16

Injuries of the Shoulder Girdle

** DISLOCATION OF THE STERNO-CLAVICULAR JOINT

Depending on the nature of the force the sternal end of the clavicle passes forwards or backwards. Both injuries are rare.

FORWARD DISLOCATION

A downward force on the point of the shoulder such as happens in a fall from a horse, levers the sternal end of the clavicle forwards and upwards.

There is an ill-defined lump over the joint, although it may be difficult to be sure that the sternal end of the clavicle is in advance of the manubrium. Arm movements cause pain. The maximum point of tenderness is on the joint; this distinguishes a dislocation from a fracture of the sternal end of the clavicle where the tenderness is one inch lateral to the joint.

Treatment

While the arm is being pulled away from the side the medial end of the clavicle is pressed backwards and downwards. After reduction a pad, held in position by *strapping may be applied as a placebo but often the displacement recurs* from the pull of the sternomastoid muscle. The failure to hold reduction does not lead to any loss of function. A lump persists, and it is wise to warn the patient of this beforehand (fig 39) To assure the patient that everything has been done to prevent recurrence it is well to keep a woman recumbent with her arm bound to the side for a few days and to instruct her to hold the medial end of the clavicle down with her other hand whenever she lifts or turns her head. A man, for whom deformity is of less moment, is got up with his arm in a sling Free use is allowed after ten days.

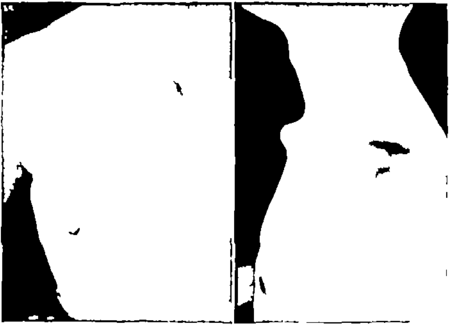


Fig 39. Persistent subluxation of the sterno-clavicular joint.

Fig 40. Fracture of the sternal end of the clavicle.

Prognosis

There is a long period of weakness of the arm. Arm movements in time become full and painless. Occasionally on account of damage to the intra-articular cartilage, the joint remains painful and clicks. Removing the cartilage cures the symptoms. Sometimes the joint subluxates whenever the patient elevates his arm. This can be cured by threading a strip of fascia through holes drilled in the clavicle and manubrium, and tying the bones together

BACKWARD DISLOCATION

A force strikes the front of the chest driving the clavicle directly backwards. Several ribs are broken at the same time, and shock is profound. The force may also travel along the clavicle from the shoulder region, as when a man is lying on his side and another man falls on him.

The local signs may be masked by the general condition The patient has severe pain and a tight feeling in the throat. There may be difficulty in swallowing and pressure on the innominate vein may cause cyanosis and oedema of the face.

Treatment

Closed reduction is attempted first. A sandbag is placed between the scapulae and the shoulders pressed back. Reduction once obtained is stable. If manipulative reduction fails, the clavicle is exposed, gripped with lion forceps and pulled forwards into position.

* FRACTURE OF THE STERNAL END OF THE CLAVICLE

This is not a common injury The mechanism is the same as for a dislocation of the sterno-clavicular joint. A blow on the front of the shoulder tends to lever the sternal end of the clavicle forwards; the clavicle remains in position and the shaft breaks instead, about one inch lateral to the joint (fig 40) The injury is seen in jockeys and footballers.

There is swelling over the medial end of the clavicle, and the point of maximum tenderness is lateral to the joint. It is often difficult, without a radiograph, to distinguish this fracture from a dislocation of the joint.

Treatment

Reduction is not necessary and splintage is not required because the sternomastoid muscle acts as an effective splint in fact, no treatment at all is required A sling may be allowed for a few days Full movements of the shoulder girdle are regained in seven days if active exercises are begun immediately

* FRACTURE OF THE SHAFT OF THE CLAVICLE

This is common in children and young adults. A fall on the outstretched hand forces the lateral end of the clavicle backwards and the shaft snaps at its middle.

It is a hinge fracture. The fracture line is transverse, often with a spike on one fragment Usually there is a third fragment which occupies any position it may be athwart the two ends and it may project under the skin (fig 41)

IN YOUNG CHILDREN

A fracture of the shaft of the clavicle is common in young children, and is worthy of separate consideration at this age.

To one unaccustomed to the injury the diagnosis is not simple. Symptoms and signs are few and it may not be known that the child has had a fall. The child cries when the arm is moved, but there is nothing to focus attention on the collar bone (fig 42). Careful palpation elicits local tenderness, but often there is no lump to be felt. The radiograph may mislead because the fracture is often greenstick and is not easily seen. If the diagnosis is missed the child is brought up again in ten days by an angry mother who points accusingly at a large lump on the clavicle.

Treatment

None is required. The arm is put into a sling for a week The mother is told that there is no harm in dressing the child and that the child should not be discouraged from taking its hand out of the sling and using it It is most important to foretell the appearance of a lump and to assure the parents that it will disappear Within a year it is impossible to say which clavicle was broken.

IN ADULTS

The diagnosis is never in doubt. The patient arrives supporting the arm and refers his trouble to his collar bone, over which there is local tenderness and a lump

The medial fragment is tilted up by the pull of the sternomastoid muscle, and the lateral fragment is depressed by the weight of the arm. The ends are overlapped and there is often a forward bow The third fragment may be in any position (fig 41).

Reduction

It is foolish to attempt to get perfect alignment. The position of the two ends is immaterial provided that there is no forward bow and no projection of bone under the skin The disability from a malunion is entirely cosmetic. If therefore the alignment feels good, do not attempt to improve the position. If there is a forward projection it is worth while under local anaesthesia improving the contour by pressing backwards on the region of the lump with the palm of the hand.

Splintage

Although numerous methods have been tried not one holds the bones in anatomical position, and it is better not to try the impossible but to rely on a

Fig 41 Fracture of clavicle. Note: intermediate third fragment. Interval, five months.

Fig 42. Fractured clavicles. The mother did not know that the child had broken the other clavicle ten days or so before.

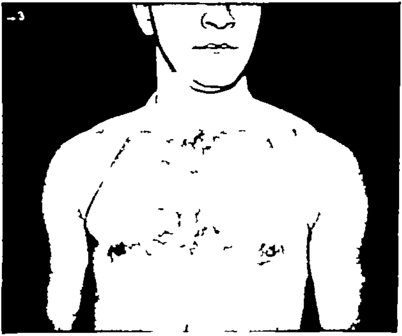


Fig 43 Figure-of-eight strapping for fractured clavicle.

simple figure-of-eight bandage (fig 43) This, by its pressure on the clavicle lessens the lump and also, by holding back the shoulder girdle, prevents excessive overriding of the fragments. To be effective the figure-of-eight bandage must be tight, and where it cuts into the front of the axilla the skin chafes. The bandage should therefore be released every day while the patient sits bracing his shoulders back. The armpits can then be washed and the skin attended to The patient is allowed up with his arm in a sling He should be encouraged to move his shoulder from the start, and within a week he should have regained full movement (figs. 44a, 44b). In three weeks the figure-of-eight is discarded. The fracture is now united although no sign of repair is visible in the radiograph. Return to work depends on the patient s occupation a clerk may not lose a day s work, whereas a soldier will not be able to fire a rifle for three months.

Complications

Recovery should be perfect. Limitation of movement at the shoulder is the only thing to fear and nowadays this is avoided by early active movements.

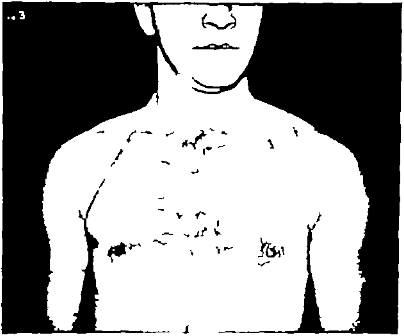
Some malunion is inevitable. There is always a lump which however gets smaller and is seldom conspicuous even in a woman (figs. 45a, 45b) In the case of a young woman with elegant shoulders and a fussy mother an attempt may be made to reduce the amount of definitive callus by preventing movement at the site of the fracture during repair This can be done by keeping the patient in bed on her back and forbidding her to lift her head or to use the arm on the affected side for three weeks. Few patients are willing to submit to this drastic treatment.

Non-union which is rare, is due most often to the futile interference of an ignorant surgeon, who has operated either to get better alignment or because he had been duped by the absence of callus in the radiograph into thinking that repair was not taking place (fig. 46)

The brachial plexus in the ordinary fracture escapes damage because the bone is bent forwards and not backwards. Occasionally pressure from callus causes a temporary mild weakness of the muscles of the arm. If as sometimes happens when a person is thrown from a motor cycle, the bone is broken by direct violence the nerves suffer severe damage.

A spike of bone may project under the skin and render uncomfortable the wearing of braces. The projection gets smoothed off in time and the symptoms rarely warrant interference.

Fig. 42. Fractured clavicles. The mother did not know that the child had broken the other clavicle ten days or so before.



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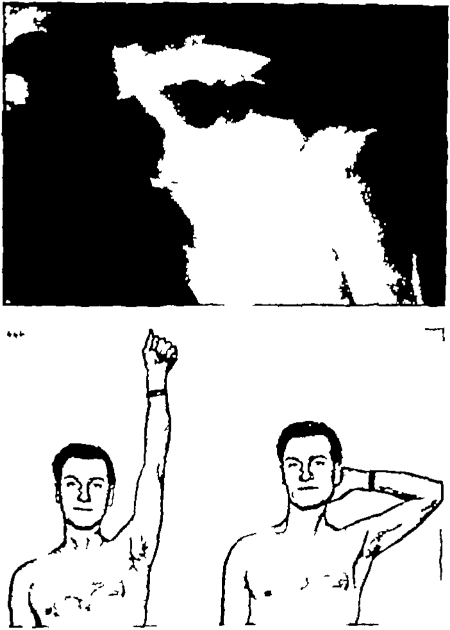


Fig. 44. *a* (*top*) Fracture of the clavicle; *b* (*bottom*) range of movement at end of one week.

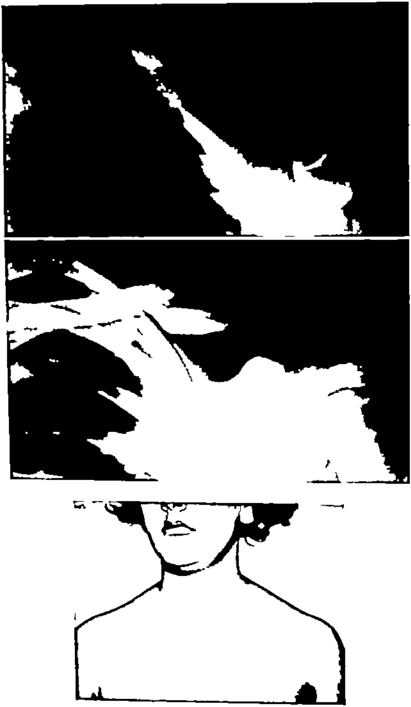


Fig 45 *a* (*top*) Fractured clavicle in a young woman. Treated by early movements. Interval one year *b* (*bottom*) cosmetic result.

Fig 46 Ununited fracture of the clavicle. The patient was treated originally in a shoulder spica plaster

Fig 47 Subluxation of the acromio-clavicular joint. Normal joint for comparison.

DISLOCATION OF THE ACROMIO CLAVICULAR JOINT

This injury which is caused by a fall on to the point of the shoulder is common among horsemen and rugger players There are two kinds subluxation or partial, and dislocation or complete

• SUBLUXATION

This is much the commoner type. The coraco-clavicular ligaments remain intact. Displacement is therefore only slight, and the joint remains stable.

The lateral end of the clavicle can be seen and felt projecting half an inch under the skin. Sometimes the displacement is obscured by swelling and the diagnosis is revealed by tenderness of the joint. The clavicle is stable and cannot be shifted backwards and forwards. A radiograph shows displacement, but since there is always a gap between the clavicle and the acromion a comparison should be made with the joint on the other side to decide whether the gap is greater than normal (fig 47)

Treatment

Reduction is easily effected by elevation of the shoulder but slight upward displacement recurs however long the subluxation is held reduced, and as this degree of displacement causes no disability it is reasonable in treating a man to do nothing beyond resting the arm in a sling and regaining as soon as possible full movement at the shoulder In a woman, in order to reduce the size of the definitive lump the subluxation should be held reduced for six weeks by slinging the arm to the clavicle. A pad of zopla felt is placed over the lateral half of the clavicle and another pad under the point of the elbow and the two pads firmly approximated by a webbing strap fastened with a buckle (fig 48) To prevent the sling from slipping off the shoulder a loop of webbing is carried round the chest under the opposite armpit, and the webbing is safety pinned to the zopla pad. The buckle is released every day while the patient is lying down and the shoulder joint exercised, the masseuse firmly pressing down on the lateral end of the clavicle throughout the movements. The sling is ineffective if slack, it must be buckled as tightly as the patient will tolerate. Unless this is attended to, the method is not worth using

•• DISLOCATION

In this type the coraco-clavicular ligaments are torn and the displacement in consequence is great. There is instability of the joint, the end of the clavicle riding free high above the acromion.

The lateral end of the clavicle is seen and felt under the skin displaced upwards and backwards. The clavicle can be wagged to and fro

Treatment

The dislocation reduces easily on elevation of the arm but cannot be held reduced by any method of external splintage. Accordingly a wire or screw is passed through the acromion across the joint and into the clavicle (figs. 49a, 49b) The wire or screw is buried under the skin. Its removal entails another small operation. Fixation by metal enables all splintage to be dispensed with, and movements at the shoulder can be started immediately without hindrance. The joint does not appear any the worse for having been penetrated by the metal

In untreated cases where the clavicle has been allowed to ride free the patient may complain of pain *Excision of the distal inch of the clavicle removes* the disfiguring lump and gets rid of the symptoms.

** FRACTURE OF THE ACROMIAL END OF THE CLAVICLE

As a result of a fall from a horse there is a direct blow on the point of the shoulder If the blow lands on the acromion it causes a dislocation of the acromio-clavicular joint and if on the lateral end of the clavicle a fracture. There are two kinds, both uncommon, lateral and medial

LATERAL FRACTURE

The line of fracture passes lateral to the coraco-clavicular ligaments. The medial fragment is held in position by the ligaments, and displacement is therefore slight (fig 50)

There is tenderness over the lateral end of the clavicle, but without a radiograph it is difficult to distinguish this fracture from a subluxation of the acromio-clavicular joint.

No treatment is required A sling may be used for a few days. Active movements of the shoulder are begun immediately

MEDIAL FRACTURE

The line of fracture passes medial to the coraco-clavicular ligaments. The medial fragment is no longer securely fastened to the coracoid process, and displacement is therefore great (fig 51)

The lateral end of the clavicle appears to be displaced upwards and backwards to form a lump under the skin Without a radiograph it is almost impossible to distinguish this fracture from a dislocation of the acromio-clavicular joint.

Treatment is difficult because although elevation of the arm brings the lateral fragment on a level with the medial the medial is still displaced behind the lateral. The position, however is good enough if it can be maintained. This is difficult. The arm should be slung to the clavicle by webbing and buckle, as for a subluxation of the acromio-clavicular joint (fig 48).

Union is insecure because the fragments unite side by side and not end on,

Fig. 48 Strapping for acromio-clavicular subluxation

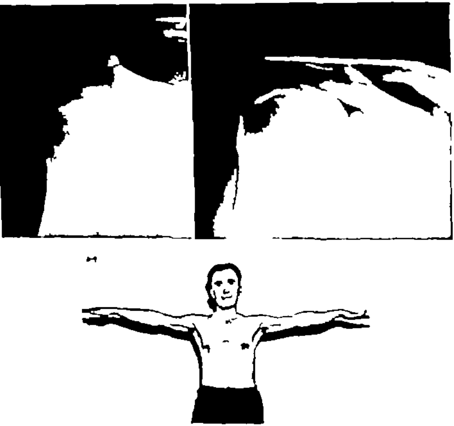


Fig. 49. *a* (*above*) Dislocation of acromio-clavicular joint. Pinned.
b (*below*) four months later

Fig. 50. Fracture of the acromial end of the clavicle, lateral to the ligaments.

Fig. 51 Fracture of the acromial end of the clavicle medial to the ligaments.

and the union is easily broken by the weight of the arm Refracture leading to non-union is not uncommon and operative reduction and fixation is sometimes necessary This can be a troublesome fracture

FRACTURES OF THE SCAPULA

Only two need to be considered fracture of the body and fracture of the neck

FRACTURE OF THE BODY

This is caused by a crush and the ribs may be damaged at the same time Local trauma is evident, but the diagnosis is only made for certain by the radiograph (fig 52).

Treatment is not needed. Active movements of the shoulder girdle should begin at once. Recovery is rapid.

FRACTURE OF THE NECK

This is caused by a blow on the shoulder The line of fracture runs from the supraclavicular notch to the axillary border just below the glenoid (fig 53) The lateral fragment carrying with it the arm is displaced downwards.

Diagnosis is difficult. The shoulder is swollen and movements are painful Having excluded a dislocation of the shoulder by observing that the elbow can be made to touch the chest wall, one postpones further examination until after a radiograph has been seen

Treatment

More attention needs to be paid to the joint than to the fracture. It is better in fact to disregard the fracture and simply to rest the arm in a sling and to begin at once active movements of the shoulder The displacement persists but the patient regains full range of movement at the shoulder at the end of ten days, and recovery will be perfect.

Fig. 52. Fracture of the body of the scapula.

Fig 53 Fracture of the neck of the scapula.

Injuries around the Shoulder

• DISLOCATION OF THE SHOULDER

Dislocation of the shoulder is rare in children and common in adults. There are two varieties: anterior and posterior

ANTERIOR DISLOCATION (SUBCORACOID)

This is by far the commoner The head of the humerus is levered out of the socket by sudden uncoordinated muscle action during a fit or a fall. The head passes forwards and downwards, and lies under the coracoid process (fig 54). A posterior dislocation may be partial, an anterior dislocation is always complete.

An anterior dislocation of the shoulder is often missed. This is surprising considering that the three characteristics of a dislocation are prominent, namely abnormal contour abnormal attitude, and immobility

The silhouette of the shoulder as viewed from the front is altered. The normal uniform curve is broken by two sharp angles one at the point of the shoulder and the other above the insertion of the deltoid (fig 55). The attitude is abnormal the arm is held away from the side and the patient is unable to make his elbow touch the chest wall And the shoulder joint is immobile; movement between the scapula and the chest wall remains but the shoulder itself is fixed. Also, the arm appears to be longer than on the other side. It is not usually possible to feel that the head of the humerus is out of place. A radiograph leaves no doubt about the diagnosis.

Reduction

Anaesthesia is essential and although brief must be deep reduction is difficult so long as the muscles retain any tone While an assistant (the anaesthetist will do) pulls on the abducted arm, the doctor presses backwards with his thumbs on the head of the humerus in the direction of the socket (fig. 56).

When the doctor is single-handed he must use Kocher's method. The elbow is flexed and the shoulder is very very slowly externally rotated this gradually *stretches the shortened internal rotators. When full external rotation has been* reached the elbow is lifted forwards and carried across the chest until the hand can be placed on the opposite shoulder During the movement the head glides back into place In Kocher's method the humerus is submitted to a rotation force and may be broken for this reason the method is not recommended.

Usually the doctor is not in any doubt whether he has reduced the dislocation. In any case the patient knows for sure as soon as he recovers consciousness because the pain has gone and the shoulder moves freely

After-treatment

As a general rule a dislocation after reduction should be treated as a sprain, and full normal range regained by active exercises as soon as possible. Immobilisation is not necessary because the muscles are able to guard against all movements likely to put tension on the repairing ligaments If the patient cannot voluntarily abduct his shoulder to a right angle at the end of a week there has been other damage in addition to a dislocation

Recurrence after dislocation of the shoulder is common, and many surgeons believe that holding the arm internally rotated for three weeks avoids this. This sounds reasonable but it must be remembered that immobilisation prolongs the period of disability

Fig 54. Anterior dislocation of the shoulder

Fig 55 Dislocation of the shoulder

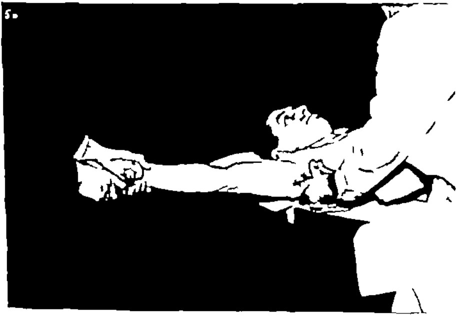


Fig 56 Method of reducing anterior dislocation of the shoulder

Complications

Recovery from an uncomplicated dislocation is complete in two weeks. Unfortunately complications are frequent and they entirely alter prognosis.

Recurrence This is common. See page 118

Stiff shoulder Provided that the patient is allowed and encouraged to move his shoulder limitation of movement should not occur with an uncomplicated dislocation of the shoulder Failure to move the shoulder is the commonest cause of stiffness

When in addition to the dislocation the fixator muscles of the shoulder are torn the return of active movement is slow and since it is some time before the patient is able to use these muscles the shoulder gets stiff Movement does eventually return but it may be grossly limited even at the end of six months. Recovery cannot be hastened The patient must not be bullied. Forced stretching by a physiotherapist is harmful active stretching by the patient's own muscles is probably helpful.

Fracture of the great tuberosity This is an avulsion fracture. The external rotator muscles are pulled on and the piece of bone into which they are inserted is avulsed from the head of the humerus. This can only be diagnosed from a radiograph. As a rule the fragment returns to its bed as the dislocation is reduced (fig 54).

When there is no displacement after the dislocation has been reduced, the fracture is disregarded. When there is wide separation it is advised that the patient should wear an abduction splint until he can hold his arm out at right angles. Internal fixation of the fragment by a screw is perhaps better treatment

Fracture of the neck of the humerus In the presence of a fracture a dislocation is apt to be overlooked since two signs of a dislocation are not present: the elbow can be made to touch the side and the shoulder appears to move.

The presence of a fracture of the neck makes reduction by the Kocher's method impossible, and for that reason a dislocation should always be X rayed before reduction is attempted. Direct backward pressure on the head of the humerus usually succeeds in reducing the dislocation. Afterwards the fracture is treated secundum artem (see page 123).

Paralysis of the deltoid Unless damage to a nerve is at once reported to a patient he is apt to hold the doctor responsible for the injury The circumflex nerve should be tested immediately after reduction by seeing whether the patient can contract his deltoid Sometimes it is easier to detect that the deltoid is working by supporting the arm a little way from the side and asking the patient to put his elbow to the side; the deltoid is felt to relax, and if the patient is then immediately asked to lift his elbow away from his body the muscle is felt to harden.

When there is paralysis or weakness of the deltoid the traditional method is to rest the arm in an abduction splint until the patient has recovered the power of holding the arm at right angles to the trunk. This unsightly and awkward

splint is however unnecessary Recovery is not jeopardised by resting the arm in a sling While recovery is awaited the shoulder must not be allowed to stiffen. Swinging exercises in the stooping position are practised.

Injury to the brachial plexus The brachial plexus itself is not infrequently injured The injury is mild, but indefinite anaesthesia of the fingers and weakness of the muscles of the hand are not unusual The nerves as a rule recover within a few months.

Avulsion of the fixator muscles Whenever a shoulder moves out of its socket the fixator muscles must inevitably be severely stretched. Sometimes the attachment of the supraspinatus is avulsed from the head of the humerus This is not revealed by the radiograph unless a flake of bone has been pulled off (fig 54).

When the avulsion is complete the tendon should be reattached to the head of the humerus at open operation But since it is difficult to know whether the avulsion is partial or complete it is better to be conservative and only to operate if the radiograph shows a flake of bone displaced between the head and the acromion process, or if the patient is unable to move his arm away from the side two weeks after the accident.

Traumatic myositis In the act of dislocation ligaments may be torn and tendons avulsed in addition, muscle fibres may be stretched to the point of tearing The amount of damage to muscle can be gauged by the amount of pain experienced after the reduction by voluntary movement of the shoulder When movement is painful no good comes of forcing it Forced movements including so-called passive movements are never permissible. The patient should be coaxed to contract his shoulder muscles; if he is prevented by pain the attempt should be given up for the time being and the arm rested until the muscles have recovered.

Although forced movements are harmful and lead to increased haemorrhage and fibrosis within the muscles, complete immobility is equally harmful and should not be continued for longer than necessary Forced movements and complete immobility are both detrimental but the patient can do himself no harm by trying to move the shoulder for he will not put irritable muscles into action. It is safe therefore, to encourage active movements from the beginning

Diffuse calcification (myositis ossificans) is a rare sequel to traumatic myositis. Loss of movement in these cases is severe and permanent.

Damage to the axillary artery The large vessels as a rule escape injury However the axillary artery may be torn. This is recognised by large haematomata around the shoulder and the formation of a false aneurysm. If the complication is not recognised the patient may bleed to death. The damaged artery needs to be tied it sometimes is a desperate operation

POSTERIOR DISLOCATION

A posterior dislocation is uncommon, and it would be of little interest but for the fact that it is nearly always missed. There are two varieties: complete or subspinous dislocation and partial or internal-rotation subluxation.

SUBSPINOUS DISLOCATION

The diagnosis of the complete dislocation, the rarer type, is relatively easy because the dislocation is complete and the head loses all contact with the glenoid cavity.

The contours of the shoulder are abnormal whether viewed from above or from the front, and the head can be felt as a bulge behind the joint. A radiograph shows clearly that the joint is dislocated.

The dislocation is reduced by a combination of traction on the arm at right angles to the body and direct pressure on the head of the humerus from behind.

INTERNAL ROTATION SUBLUXATION

This is easily overlooked. The head of the humerus remains in contact with the rim of the glenoid but is much internally rotated. No movement can be elicited at the shoulder and the arm is fixed in internal rotation. Alteration in contour is not easy to observe. The silhouette from the front may appear normal, although if the shoulder is viewed from above the posterior prominence made by the head of the humerus is more marked than usual. Palpation is often unhelpful. The antero-posterior radiograph is characteristic: the humerus is in its normal position but rotated so that the head is flask-shaped (fig. 57a). A lateral radiograph if obtainable shows the subluxation clearly (fig. 57b).

Reduction is easily effected by rotating the arm out while the head of the humerus is pressed forwards.

UNREDUCED ANTERIOR DISLOCATION OF THE SHOULDER

Reduction becomes more difficult with every day's delay and after about six weeks the risk of fracturing the neck of the humerus or of tearing the main vessels and nerves, which are closely adherent to the head, renders it dangerous to attempt.

If the dislocation is left unreduced little shoulder movement will return but movement between the scapula and the chest wall is sufficient to allow of some abduction of the arm, and function may not be greatly impaired considering the age and habits of the patient. Therefore, if there are no pressure symptoms the dislocation is best left undisturbed (fig. 58). If the patient complains of symptoms due to pressure of the head on the nerve trunks an exploratory operation is justifiable; at which the surgeon decides whether to attempt reduction or to excise the head or to arthrodese the joint. The result in any case is likely to be poor.

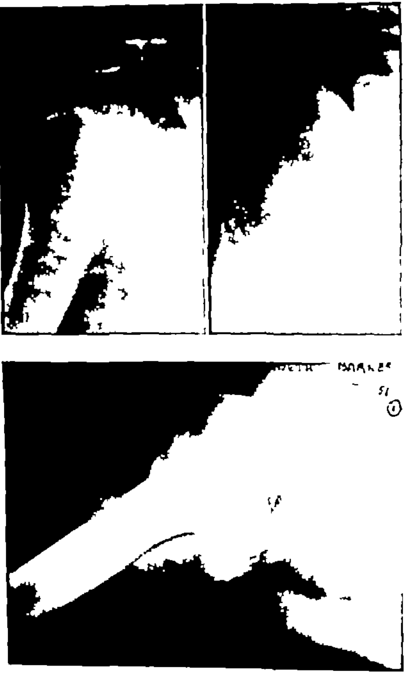


Fig 57 *a* (*top*), Posterior dislocation of the shoulder right, normal.
b (*bottom*) lateral view

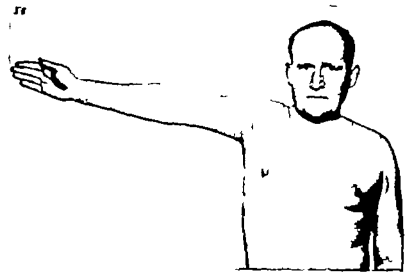


Fig 58 Unreduced dislocation of the shoulder showing range of abduction.

RECURRENT DISLOCATION OF THE SHOULDER

After the replacement of an anterior dislocation the shoulder ordinarily remains stable; sometimes the dislocation becomes habitual. The sufferers are epileptics and young athletes. It is remarkable how well developed the shoulder muscles are. The first dislocation is nearly always complete and follows trauma. But the trouble may appear insidiously the head of the humerus at first riding forwards on the rim of the glenoid and then slipping back into the socket This may happen without a major injury The head of the humerus does not pass through a hole in the capsule but is enabled to ride forwards because the labrum has become detached from the rim of the glenoid.

Recurrence is at first associated with unusual muscle exertion but later gets more frequent In the end the exciting cause becomes trivial and the joint dislocates when the patient sneezes or turns over in bed. The dislocation is often reducible without anaesthesia and often the patient learns the knack of reducing it himself

The cause is not established. Stretching of the capsule at the initial injury is an unlikely cause because simple reefing operations fail to cure and also because a joint is preserved from dislocating in the ordinary way not by the strength of its ligaments but by the protective action of the overlying muscles. It has been suggested that the head as it passes forwards at the first dislocation detaches the labrum from the glenoid rim and that the tear never mends. This cannot be the sole explanation because sometimes the capsule at operation is seen to be firmly attached to the fibrocartilage and the fibrocartilage firmly attached to the bone.

A radiograph taken with the arm internally rotated shows a flattening of the posterior part of the articular surface of the humerus. This defect is as likely to be the result as the cause of the recurrence; and in patients who are cured by operation the defect still remains. The liability to recurrence is not in our experience affected by the way in which the original dislocation is treated.

Treatment

Bone setters claim to cure recurrent dislocation of the shoulder by manipulation, and there is no doubt that many of their patients believe they are cured. It may be that sufficient time has not been allowed to test the supposed cure, for it is well known that the shoulder may not dislocate for several years if the patient does not engage in games or work calling for external rotation of the abducted arm. It is, however possible that manipulation cures a recurrent dislocation by stretching or breaking adhesions that prevent the head from sinking into the centre of the socket when the fixator muscles go into action.

Most doctors are convinced that surgery alone cures, although they may not agree on the best operation The two most popular operations are the Bankhart and the Putti-Platt. That there are so many operations implies that no one is certain to cure.

In the Bankhart operation the anterior part of the capsule is reattached to the bone of the glenoid rim In the Putti Platt operation the divided ends of the subscapularis tendon are overlapped. Both these operations possibly owe their success to the creation of a mass of scar tissue, which blocks the head of the humerus as it attempts to glide forwards out of the socket.

• FRACTURE OF THE NECK OF THE HUMERUS

A fracture in this region is met with in children and in old women as the result of a fall on the hand Occasionally in a man the upper end of the humerus is smashed by direct injury

FRACTURE OF THE NECK OF THE HUMERUS IN CHILDREN

In a young child the fracture is transverse and is situated about an inch below the growth disc. When the fracture is complete the shaft passes up in front of the upper fragment and overlaps it (figs. 59a, 60) In an older child the fracture line passes through the metaphysis and partly along the growth disc (fig 61). The fragments are not separated but there is outward bowing

There is severe pain, complete loss of function and the arm is supported by the other hand. Examination is so painful that it should be deferred until after the X ray has been taken—and then it will probably not be needed.

Treatment

The angulation deformity of a fracture-separation need not be corrected. The bone remodels itself (fig. 61).

Fig 59a Fracture of the neck of the humerus in a child

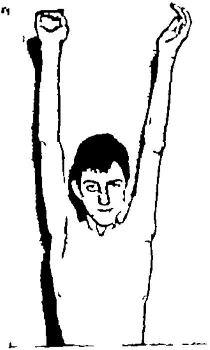


Fig 59b Sixteen months later showing movement.

When the fragments are widely separate an attempt may be made to get them to hitch. The arm is strongly adducted across the chest and while traction is being applied the upper end of the shaft is pushed outwards by a hand in the axilla. The anaesthetic must be deep enough to relax the muscles completely

Whether reduction succeeds or fails the arm is put into a sling and the shoulder rested for ten days At the end of that time shoulder movements are encouraged. No other treatment is necessary

Even though displacement is not corrected the child regains full movement at the shoulder and there is no loss of function (figs. 59b 61) In a year or so all deformity in the radiograph has disappeared (figs. 60 61).

FRACTURE OF THE NECK OF THE HUMERUS IN AN ADULT

The patients are women over middle age who fall on the outstretched hand. The line of fracture passes transversely across the surgical neck. Occasionally in a man the upper end of the humerus is smashed by direct injury

The patient complains of pain in the shoulder after a fall. The shoulder is swollen and tender and movements at the shoulder are limited or are totally absent A diagnosis can rarely be made with certainty without a radiograph. If the patient is seen soon after the accident an impacted fracture is often overlooked The symptoms are mild and the patient does not consult a doctor for

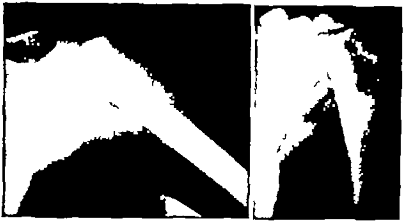


Fig 60 Fracture-separation of the upper end of the humerus. Natural remodelling. Interval: fourteen months.

Fig 61 a (above) Fracture of the neck of the humerus in a child. Natural remodelling Interval sixteen months. b (below) movement sixteen months after the fracture.

some days by then a tell tale bruise has appeared on the medial side of the arm.

Radiography enables three types to be recognised the impacted fracture the complete fracture with separation, and the comminuted fracture

In the *impacted fracture* the fragments have shifted slightly but they have not lost contact the lower fragment is usually abducted on the upper (figs. 62a, 62b).

In the *complete fracture* the shaft is shifted forwards and inwards and rides up in front of the upper fragment and is rotated in. The upper fragment is abducted and rotated out (fig 63)

In the *comminuted fracture* the fragments are impacted but in addition to the transverse fracture the great tuberosity is broken and another fragment may be split off the medial side of the head (fig 64)

Treatment

In the impacted type reduction is unnecessary The patient is given a sling for comfort, and placed under a physiotherapist who encourages her to move her shoulder

In the comminuted type reduction is not possible, and so is not attempted. Again, the patient is given a sling and handed over to the physiotherapist.

In the complete type with separation of the fragments treatment is debatable. Some surgeons try to reduce the displacement and if they succeed put on a

Fig 62 *a* (*left*) Fracture of the neck of the humerus in a woman. Impacted. *b* (*right*) lateral view

Fig 63 Fracture of the neck of the humerus in a woman. Gross displacement.

Fig 64. Fracture of the neck of the humerus in a man. Comminuted.

plaster spica for six weeks. The disability after a fracture of the neck of the humerus is stiffness of the shoulder and a better range of movement is recovered when the displacement is neglected and the patient treated with a sling and active movements. And so in effect all types of fractures of the neck of the humerus are treated in the same way

Active movements of the shoulder should be encouraged from the start. For the first few days the patient is grateful for a sling but she is apt to cling to it for too long The period of disability depends largely on the patient's efforts to move her shoulder

A full range of movement is seldom recovered and little movement can be expected in the comminuted fracture. However the loss of movement is not felt by the average patient—an old person who does not habitually use the extremes of movement at the shoulder joint.

Complications are rare.

** DISLOCATION OF THE SHOULDER WITH FRACTURE OF THE NECK OF THE HUMERUS

This is a serious injury The bone breaks either at the time of the accident or during attempts at reduction by Kocher's method.

The signs are those of a complete fracture of the neck of the humerus and the true state of affairs is only revealed by radiographs (figs. 65 66 68).

Treatment

This is often difficult and unsatisfactory Closed reduction should first be attempted. The anaesthesia must be deep enough to relax the muscles completely An assistant pulls on the arm in extreme abduction (the arm lying alongside the head) and the surgeon with his two thumbs presses the head towards the socket. When possible the joint is X rayed while the patient is still under the anaesthetic to allow of a further attempt at reduction if necessary If the head can be replaced the injury is treated as an uncomplicated fracture of the neck of the humerus.

If manipulation fails or if after reduction the articular surface is not facing the socket, open reduction must be resorted to but operative interference is likely to damage still further the blood supply and to render necrosis of the head more probable.

Sometimes the injury is treated as a fracture and the dislocation is overlooked. The delay in making the diagnosis renders treatment still more difficult. Open operation is then the only treatment available, but the chances of success are small. When reduction is not possible the head fragment may be excised. The result will be poor and the range of movement small and the patient is no better off than she would have been without any treatment for the

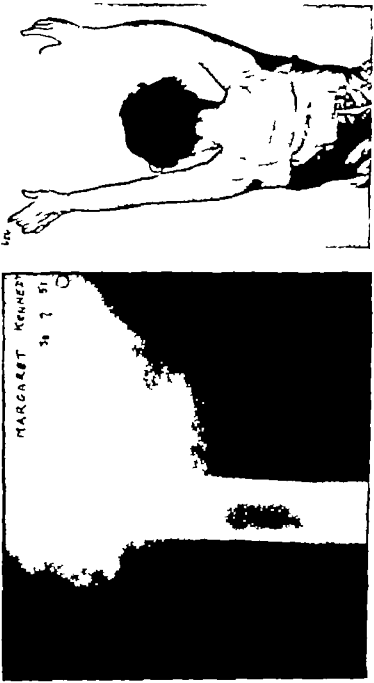


Fig. 65 Fracture dislocation of the shoulder: a (*left*) lateral view b (*right*) range of movement two and a half years after reduction of dislocation.

** FRACTURE OF THE GREAT TUBEROSITY

The great tuberosity may be broken in two ways, by impact or by avulsion

IMPACT FRACTURE

The tuberosity is driven against the acromion process when the arm is in abduction and is sheared off It is usually associated with a fracture of the neck of the humerus. A large triangular piece of bone, as seen in an antero-posterior radiograph, is separated from the shaft (fig 68) Displacement is usually slight. Diagnosis is not possible without a radiograph.

No special treatment is required. Active movements of the shoulder are begun at once. A sling may be used for a few days.

AVULSION FRACTURE

This may occur on its own or as a complication of a dislocation. The mechanism is the same as for a torn supraspinatus tendon, the external rotators are vigorously put into action while the humerus is being internally rotated. Instead of the tendon's being torn the piece of bone into which the tendon is inserted is pulled away

The avulsion may be partial. In this case there is no displacement. The fracture is shown in the radiograph as an irregular fragment, the size of a bean (fig 69). Or the avulsion may be complete. Displacement is then great, and the fragment shows in the radiograph as a narrow dense strip of bone lying between the head and the acromion.

Treatment

The partial avulsion does not require any special treatment. The patient is given a sling and encouraged to exercise his shoulder

A complete avulsion should be operated upon and the fragment of bone sewn or screwed back in place. After the operation the injury is treated as a partial avulsion.

Fig 66 Fracture-dislocation of the shoulder Reduced.

Fig 67 Fracture of the great tuberosity complicating dislocation.

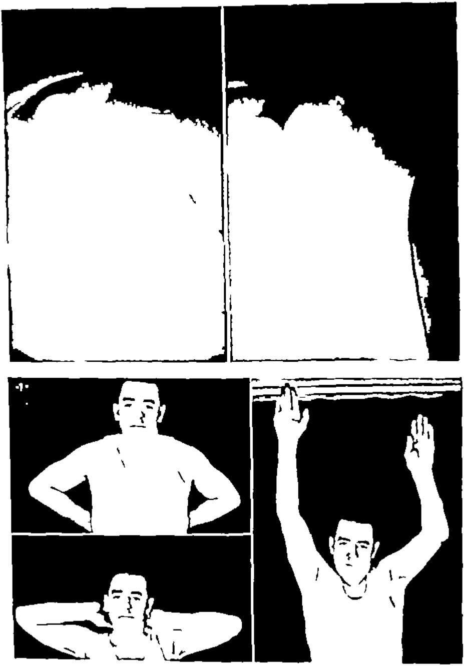


Fig. 68. *a* (*top*), Fracture-dislocation of the shoulder
b (*below*) range of movement seven and a half weeks later

Fig 69 Avulsion of the great tuberosity

Fig 70 a Birth fracture of the humerus.

18

Fractures of the Shaft of the Humerus

Fracture in the new-born
SPIRAL FRACTURE OF THE SHAFT
TRANSVERSE FRACTURE OF THE SHAFT

• FRACTURE OF THE HUMERUS IN THE NEW BORN

The humerus is not infrequently broken during a difficult delivery The baby keeps the arm at rest, the arm is swollen, and the radiograph shows a transverse fracture of the shaft without overlap

No treatment whatsoever is required. Within a few weeks the baby is moving the arm normally and the radiograph shows a massive amount of callus (fig 70a). If the humerus is X rayed again at the end of a year no trace of the fracture is to be seen (fig 70b)

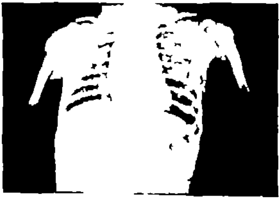


Fig 70b Birth fracture of the humerus, four months later

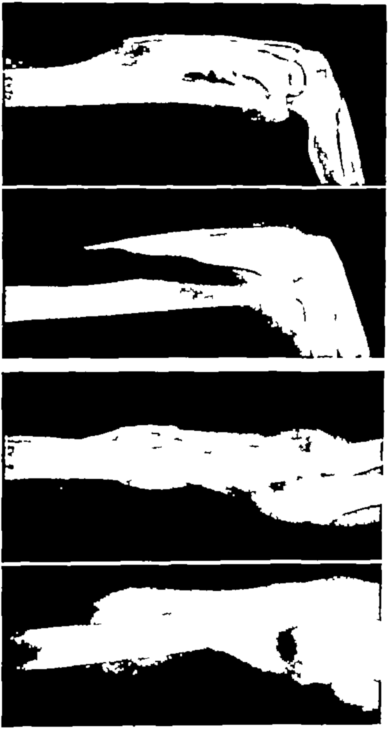


Fig 71 *a* (*left*) Spiral fracture of the humerus. Interval six months. *b* (*right*) lateral view

• SPIRAL FRACTURE OF THE SHAFT OF THE HUMERUS

This common fracture happens when the arm is twisted. The usual history is a fall on the outstretched hand. The line of fracture is a long spiral, and it may be anywhere in the bone (figs. 71a, 71b) The fracture is complete, and the two fragments are separated from one another by a gap visible in the radiograph. There is overlap and often angulation.

The arm is useless and is supported by the other hand Almost as soon as the limb is handled crepitus is felt

Reduction

The weight of the arm reduces the overlap angulation disappears if the arm is allowed to hang vertically and placing the hand on the lower part of the front of the chest corrects the rotation

Splintage

Muscles effectively hold the fragments, and alignment is automatically secured when the arm hangs free by the side of the chest. The only splintage required therefore, is a sling. The sling supports the forearm only the elbow remaining free and flexed to a right angle (fig 72) A collar-and-cuff (see page 14) should not be used for fractures of the humerus it is a splint that belongs to the elbow and to nowhere else. A collar-and-cuff by drawing the lower fragment forwards causes angulation if angulation is to be avoided the humerus must be vertical

A plaster-of paris slab extending from the axilla on the inner side, down over the point of the elbow and up on the outer side may be added if the patient or doctor feels that enough has not been done, but it is unnecessary and does not add to the comfort of the patient.

The physiotherapist starts at once to make the patient use his hand, and to teach him to contract the flexors and extensors of his elbow and at the end of a week to abduct voluntarily at the shoulder It is unnecessary and potentially dangerous for the physiotherapist to give passive movements. While the patient is moving his elbow he will hear crepitus for the first week or two, and it adds to his confidence to be warned of this by his doctor

Protection

Since the fracture is spiral there is not any danger of hinging, and active protection is unnecessary during the time that union is progressing to consolidation At the end of three weeks it is safe for the patient to put his arm through his coat sleeve, and he is encouraged to take his arm out of the sling and to use it for everything

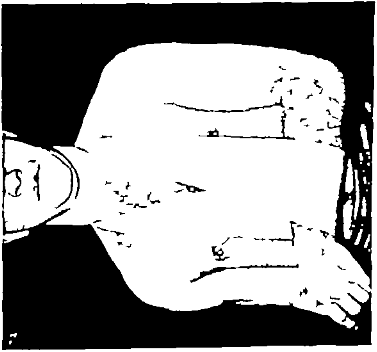


Fig 72. Forearm sling for fracture of the shaft of the humerus.

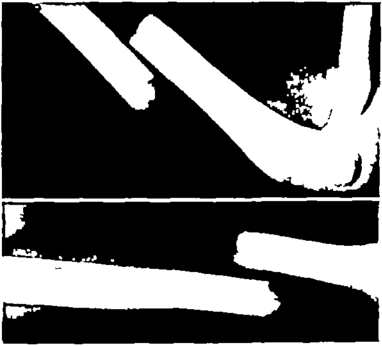


Fig 73a Transverse fracture of the shaft of the humerus.

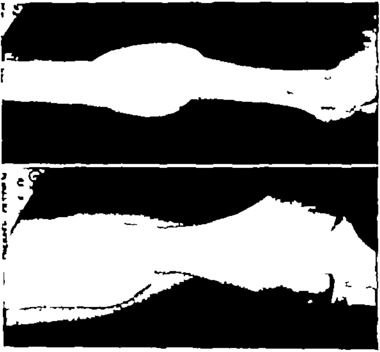


Fig 73c after three months.

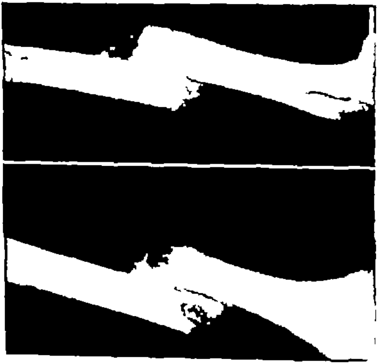


Fig 73b after seventeen days.

Fig 74. *a* (*left*) Transverse fracture of the shaft of the humerus. Plated. Interval eight weeks. *b* (*right*) patient moving his elbow three weeks after the injury

Prognosis

This is excellent. A spiral fracture of the humerus is a simple fracture to treat and does not give rise to any anxiety provided that the radiographic appearance is disregarded.

** TRANSVERSE FRACTURE OF THE SHAFT OF THE HUMERUS

This is caused by a blow on the arm. The line of fracture is transverse and the fracture is complete. The usual site is about the middle of the shaft but depends on the point of impact. Usually there is overlap. Often the fragments are wide apart and the lower fragment is angulated and rotated on the upper (fig. 73a).

The arm is useless and there are characteristic spasms of severe pain. Crepitus is felt as soon as the limb is handled.

Reduction

The weight of the arm overcomes overlap and may actually distract the fragments. Angulation and rotation automatically disappear if the forearm is supported in a sling and the arm allowed to lie free by the side of the chest wall.

Splintage

In the fear that excessive movement at the shoulder will give rise to non union the orthodox method of treatment is to immobilise the shoulder in a position of abduction by means of a plaster spica. Non union is frequently associated with this method of treatment. A transverse fracture can be treated in the same way as a spiral fracture, namely by supporting the forearm in a sling with the elbow flexed to a right angle. The elbow must not be flexed more than this, otherwise the fracture angulates. The physiotherapist begins at once teaching the patient to contract the flexors and extensors of his elbow. Abduction of the shoulder is not allowed for three weeks. At the end of six weeks the patient can hold his arm abducted at a right angle and the radiographs show a large amount of calcified callus, induced by the compression of the ensheathing callus by voluntary movements of the elbow (fig. 73b).

It might be supposed that the fracture unprotected by any splintage except a sling would be painful but after the first few days there is surprisingly little discomfort. It is as well to bind the arm to the side by a circular bandage for the first few nights. The patient is often more comfortable sleeping in a chair for a week, since in this posture the humerus is vertical.

Plating the humerus is an alternative method of treatment. The patient is made comfortable immediately and is able to move the shoulder and the elbow freely from the start (figs. 74a, 74b). There is a risk, however, of damaging the musculo-spiral nerve by traction during the operation.

Protection

Although the fracture is united at the end of six weeks protection is still needed. Being transverse this fracture is liable to refracture and must be protected against angulation stresses until consolidation has occurred. Forced movements at the elbow must be carefully guarded against. The sling should not be discarded under three months, for if the elbow has not regained full mobility and the arm is allowed to hang down unsupported, an angulation stress falls on the site of the fracture and causes a refracture.

Complications

Stiff joints A stiff shoulder and a stiff elbow frequently complicate a fracture of the shaft of the humerus. Stiffness is minimised by early active movements. Unfortunately movement at the shoulder cannot be started early in the case of a transverse fracture Loss of movement is not serious at the elbow since people do not habitually use more than a small range of movement at this joint. Stiffness of the shoulder is a disability and the patient is apt to grumble about his shoulder long after he has forgotten about his broken arm.

Delayed union This is common with a transverse fracture. The weight of the arm is sufficient to pull the bone-ends apart and the stimulus for bone repair is then lacking namely compression of the repair material The stimulus can be supplied by getting the long muscles to contract vigorously Frequently when doing this the patient says that he can hear the bone-ends grating—which is exactly what is wanted. Unless this muscle action is insisted upon, the radiograph shows what is characteristic of this fracture when treated by strict immobilisation, namely the almost complete absence of callus. If the patient has been using his muscles vigorously the radiograph shows a mass of callus (fig 73b).

A word of caution needs to be given against the use of traction for treating fractures of the shaft of the humerus. Traction is never essential, and if used delays union and may cause non-union.

If union is slow be patient Continue the sling for a longer period and stimulate the bone ends by making the patient contract the overlying muscles.

Non union This is common but for a different reason namely that angulation stress is allowed to act on the site of the fracture while union is progressing to consolidation. The angulation stresses come from two sources, abduction of the shoulder which causes lateral hinging and gravity acting on a stiff elbow which causes antero-posterior hinging The elbow being stiff cannot extend, and so the angulating force due to the weight of the forearm is transmitted to the site of the fracture.

Treatment for established non union consists of removing the fibrous tissue from between the bone-ends and freshening the ends, and then in proceeding to treat as for a fresh fracture but this time properly A bone graft may be

added as a means of internal fixation, but it is not essential except where there is a wide gap between the fragments due to a gunshot wound or to a previous operation.

Musculo-spiral palsy The nerve is frequently damaged at the time of the accident and it should always be tested soon after the accident. The lesion usually is a temporary physiological interruption and recovery takes place in a few weeks Meanwhile the wrist should be supported in dorsiflexion. It is better not to splint the knuckle joints, but several times a day the patient should extend these joints with his other hand

If recovery is delayed, further action should not be taken until after the repair of the bone. By then the nerve has usually recovered if it has not, one has to decide whether to explore the nerve with a view to suture, or to proceed at once to a tendon transplantation

19

Injuries about the Elbow

Fractures about the elbow fall naturally into two groups, those of children and those of adults. A child seldom suffers from any of the adult fractures and vice-versa. Dislocation of the elbow occurs in both children and adults.

Injuries met with in children and adults.

In children	*In adults*
DISLOCATION OF THE ELBOW	
SUPRACONDYLAR FRACTURE	T-shaped fracture of the shaft of the humerus
FRACTURE OF THE LATERAL CONDYLE	Fracture of the capitellum
FRACTURE OF THE NECK OF THE RADIUS	FRACTURE OF THE HEAD OF THE RADIUS
FRACTURE OF THE MEDIAL EPICONDYLE	—
—	FRACTURE OF THE OLECRANON

Dislocations are first considered (pp 142–5); then, fractures in children (pp 146–63) and finally fractures in adults (pp 163–71)

One should be familiar with the radiographic appearance of a child's elbow (figs. 75 76)

In the antero-posterior view four centres may be seen. a large centre for the capitellum, a tiny centre for the trochlea, not seen until the age of 10; a centre for the head of the radius; and a centre for the medial epicondyle after the age of 10. The centre for the lateral epicondyle does not appear before the age of 12 and soon afterwards merges with the shaft.

In the lateral view the humeral epiphysis is partly overlapped by the diaphysis on the medial side so that an epiphysial space is not seen. The main centre seems to be tilted forwards so that the epiphysial line is wider behind than in front. The epiphysis makes an angle of 135 degrees with the shaft, and a line drawn down the anterior border of the shaft meets the lower border of the epiphysis about its middle. The lateral view also shows a centre for the olecranon process.

An X ray of the normal uninjured side should always be asked for in a child.

Fig 75 Normal elbow Age 10.

Fig 76 Normal elbow Age 12½

• DISLOCATION OF THE ELBOW

This injury is seen in both children and adults. It follows a fall on the out stretched hand the force travels up the forearm and pushes the two forearm bones back on the humerus.

The three signs characteristic of a dislocation are present, namely abnormal contour abnormal attitude and immobility The posterior silhouette of the upper limb is abnormal the vertical line instead of inclining gently forwards in its lower half bends abruptly backwards (figs. 77 78). The arm is held at an angle of 130 degrees. And no movement at the joint, active or passive, is obtainable. The arm is not supported by the other hand as it usually is after a fracture.

The dislocation shows up clearly in a lateral radiograph (fig 79) The forearm bones are shifted backwards and either in or out and the forearm may be rotated on the humerus.

Treatment

Complete relaxation is essential. Reduction is then easily obtained by the procedure used for the reduction of a supracondylar fracture. With the patient recumbent the arm is placed vertical and the elbow is flexed. The doctor clasps the elbow in his two hands, the fingers round the front of the humerus and the thumbs behind on the olecranon process. By means of the thumbs the olecranon *is first shifted sideways so that it lies directly behind the humerus; it is* then pushed forwards over the lower end of the humerus (fig 80). The dislocation reduces with a jolt.

Fig 77 Normal silhouette of the back of the elbow

Fig 78. Silhouette after a dislocation.

Fig 79. Dislocation of the elbow

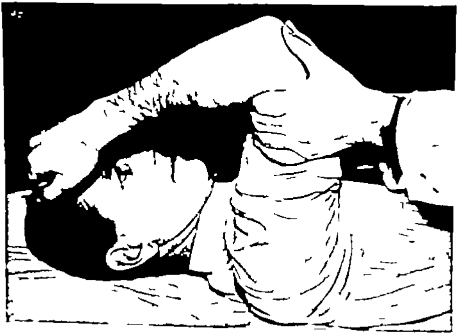


Fig 80 Method of reducing a dislocation of the elbow

After reduction the stability of the joint is tested. If stable fixation is not required. If unstable, a posterior plaster-of paris slab is moulded to the back of the arm and forearm with the elbow flexed.

As soon as the patient recovers from the anaesthetic the nerves are tested, and an X ray taken to ensure that reduction is exact and to see what associated fractures there are If there are not any fractures the elbow is rested in a sling for a few days and active movements are encouraged at once. So long as there are not any complications prognosis is excellent. The elbow gradually recovers full movement.

Complications

Incomplete reduction A sideways displacement may persist after the backward displacement has been corrected (fig 81). And if the reduction has not been checked by a radiograph the doctor and the patient remain in blissful ignorance until, with the disappearance of the swelling, the bony outlines of the elbow demonstrate that all is not well. Reduction at this stage can only be obtained at open operation.

Calcification in ligaments and muscles. Small deposits of calcium in the capsule are frequently seen after a dislocation (fig. 82) They cause some permanent loss of movement, which is not necessarily proportional to the amount of the deposit seen in the radiograph. Fortunately the ordinary person does not habitually use the extremes of movement at the elbow and he may not notice the loss.

We do not know why calcification occurs or how to avoid it. Attempts to force movement at the elbow create more calcification and result in still less movement. A dislocated elbow should be carefully watched for the first few weeks after reduction. If the range of movement at any time gets less, elbow movement should be forbidden for a few days. Immobilisation is continued until unrestricted use of the joint does not diminish its range.

Associated fractures These are present as often as not. There may be a fracture of the head of the radius, a flake off the capitellum a fracture of the coronoid or a fracture of the medial epicondyle.

If the head of the radius is comminuted it should be excised. A medial epicondyle may be trapped inside the elbow joint. If so, it should be extracted at an open operation and discarded, the muscles fixed to it quickly gain new attachments. Fractures other than these are disregarded. In spite of their sinister appearance they make little difference to prognosis

Nerve injuries Any of the three main nerves may suffer damage. When the forearm bones are displaced sideways as well as backwards the ulnar nerve must undergo considerable stretching, yet it often gets off scot free.

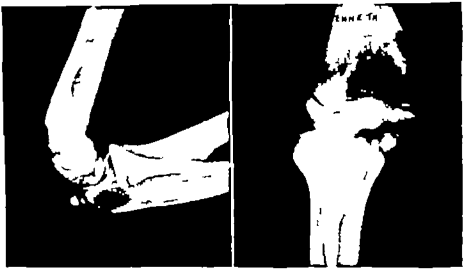


Fig 81 *a* (*left*) Dislocation of the elbow *b* (*right*) incomplete reduction. Lateral shift of the forearm bones. Medial epicondyle displaced into the joint.

Fig 82. Calcification in the capsule after reduction of a dislocation.

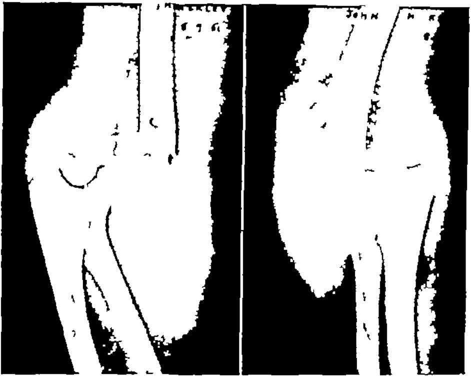
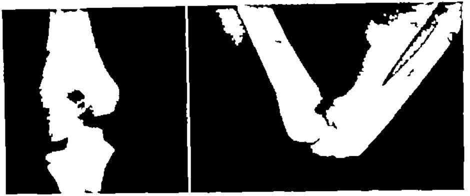


Fig 83 *a* (*above*) Supracondylar fracture *b* (*below*) reduced, *c* (*opposite page*) three months later



* SUPRACONDYLAR FRACTURE OF THE HUMERUS

Fracture of the humerus just above the elbow is a common injury in child hood. It follows a fall on to the outstretched hand. There are two varieties: with backward displacement, and with forward displacement.

SUPRACONDYLAR FRACTURE WITH BACKWARD DISPLACEMENT

This is by far the commoner The line of fracture is transverse and runs through the metaphysis just above the epiphysial line. Sometimes the fracture is incomplete and the lower fragment is only tilted backwards. More often the fracture is complete and the lower fragment, carrying with it the elbow and forearm, is displaced backwards and upwards (fig 83a). In addition it may be shifted sideways and angulated, and it is nearly always rotated so that in a lateral radiograph one sees the front aspect of the upper fragment and the side aspect of the lower fragment (fig 84).

When the fracture is complete the contour of the arm is abnormal. The silhouette of the back of the arm instead of inclining forwards as it approaches the elbow is straight. The child supports the arm with the other hand. A finger moved down the posterior aspect of the arm comes across an area of local tenderness just above the elbow The child resents examination and it is kinder to rely on a radiograph for the exact diagnosis.

Reduction

Before reducing the backward shift and the backward tilt the doctor should correct angulation and rotation. The forearm is nearly always internally rotated on the humerus this is corrected by rotating the forearm out at the elbow It is more important, however to correct angulation. There is frequently an out ward bow at the fracture site Accordingly before flexing the elbow prepara tory to the main reduction the arm is extended as much as possible and any

cubitus varus converted into a normal carrying angle. The doctor then proceeds to reduce the main displacement. He takes up the position shown in the picture (fig 80): the patient's humerus is vertical and his elbow is allowed to flex. The doctor clasps the elbow with his two hands, his fingers around the front of the shaft of the humerus and his thumbs behind on the distal fragment. With his two thumbs the doctor pushes the lower fragment forwards. The advantage of this simple method is that the doctor is able to feel the lower fragment glide forwards into position, and he knows for sure that he has been successful. The method is equally effective whether the fracture is incomplete or complete. Open operation is never necessary in a recent supracondylar fracture in a child.

After he has felt the lower fragment grate forwards the doctor should, while holding the reduction by grasping the lower end of the humerus, extend the

Fig 84. Supracondylar fracture Lower fragment rotated

elbow as far as it will go. This enables him to check whether angular deformity has been corrected.

An X ray should be taken soon after the reduction. It is often disappointing. Luckily accurate reduction is not required. So long as there is no angulation at the site of the fracture in the antero-posterior view (fig 85), and no forward bowing in the lateral view reduction is satisfactory. The fragments must be made to hitch, but lateral shift and backward shift are unimportant.

Splintage

The classical collar and-cuff maintains reduction (fig 15). Pieces of bandage are tied around the neck to form a collar and around the wrist to form a cuff and the collar and cuff are connected together by another piece of bandage. Both the collar and the cuff are more comfortable if they are rolled to form a tube and the inside is stuffed with cotton wool. The elbow should be flexed sufficiently to allow the hand to touch the mouth, if this obliterates the pulse

Fig. 85 Supracondylar fracture after reduction. Angulation not corrected.

the flexion is lessened. For greater security a plaster slab may be moulded to the back of the arm and forearm immediately after reduction while the humerus is still vertical but care must be taken that the bandage securing the plaster does not press into the front of the elbow A large blister appears within a few days on the medial side of the elbow and the mother is warned that serum from this may stain the bandage.

The collar-and-cuff is retained for three weeks. If flexion of the elbow has had to be lessened on account of a threat to the circulation the collar and-cuff should be gradually approximated in the course of the first week, as the swelling around the elbow lessens, until the hand is able to touch the mouth.

Protection

The fracture unites in three weeks, but protection is needed until the fracture has consolidated. The patient must not risk another fall, and movements at the elbow must be gentle for another three weeks. The elbow is carried in a sling until six weeks have elapsed since the accident, although the child is encouraged to take the arm out of the sling and use the hand.

When the collar and-cuff is discarded at the end of the third week the elbow is stiff Movement must be allowed to return of its own accord. Attempts to hasten the return of movement by force irritate, and produce more infiltration of the capsule with repair tissue, and the result is less rather than more movement.

If when the elbow is freed the child loses the ability to touch his mouth the collar and-cuff should be replaced and gradually tightened until flexion is restored. After any injury to the elbow however little the ultimate range of movement it is essential to preserve the ability to get the hand to the mouth

A physiotherapist may be employed but she can do no good and may do harm. And unless the mother insists, it is better not to give any further treatment after the collar-and-cuff has been dispensed with.

Prognosis

The results are good in spite of inaccurate reduction. Even when movement is slow to return, usually at the end of a year from the accident there is a full range; and in two years it is difficult to tell from a radiograph that there had been a fracture.

Complications

Loss of movement at the elbow This may at first be due to a poor reduction, but this cannot long be a factor because growth at the epiphysial line removes the line of fracture away from the joint. Presumably the stiffness is due to fibrosis of the capsule caused by an extension into it of the ensheathing callus.

Occasionally the limitation in movement is obviously due to a myositis ossificans, but there are cases in which no apparent reason for the loss of movement can be found and the loss is permanent. It is wise, therefore, to warn the

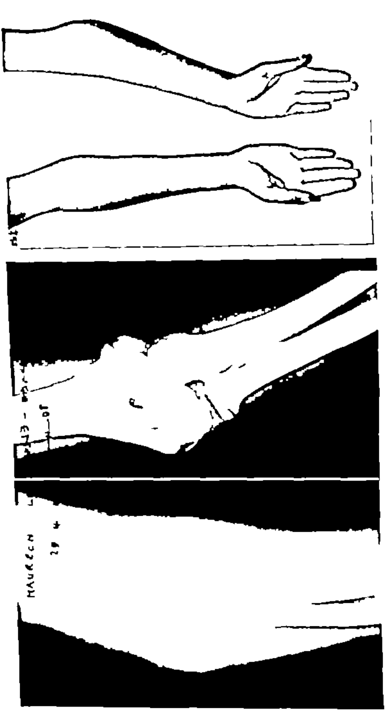


Fig 86 *a* (*left*) Supracondylar fracture angulation not corrected. Four years later cubitus varus. *b* (*right*) clinical photograph.

parents that any elbow injury is serious and that full movement may not return.

Cubitus varus Cubitus varus is often noticed as elbow movement increases. In theory the deformity might be due to irregular growth at the epiphysis, but if it is noticed soon after the elbow is freed it must be due to faulty reduction. It is an ugly deformity and should be avoided (figs. 86a, 86b) Cubitus varus can only be corrected by an osteotomy of the humerus just above the joint. Although unsightly a cubitus varus does not cause any disability and its correction is a luxury and not a necessity

Ischaemic paralysis (fig 87). This serious complication is the sequel to a temporary cutting-off of the blood supply to the forearm. The exact aetiology is obscure. The brachial artery might be struck by the lower end of the shaft as it comes forwards. Spasm of the muscular wall of the artery would be the immediate reaction to this, and the artery might be so much constricted by spasm that its lumen was obliterated. Even so the collateral vessels should be capable of supplying an adequate volume of blood. At times this alternative supply is inadequate, *possibly because the spasm extends upwards and downwards to* involve the collateral vessels, possibly because the collaterals are obliterated by the pressure of a subfascial haematoma. The condition could also be caused by too tight a plaster or by too much flexion of the elbow Ischaemic paralysis is rare, but should the doctor be unfortunate enough to meet with it, he should be in a position to prove that neither of these two contributory causes was present.

The earlier arterial insufficiency is recognised, the easier it is to avoid its consequences. Within a few hours of the injury the patient *complains of intense pain* The hand swells and acquires a dusky colour There may be numbness and the patient is unable to move his fingers. Provided that the hand is warm and a good colour swelling does not matter Neither does the absence of a radial pulse so long as there is a good circulation and normal sensation in the hand.

Immediate action is imperative. If the fracture is still unreduced it should be reduced forthwith. If the fracture has been reduced external pressure is relieved by exposing the skin along the anterior aspect of the arm, elbow and

Fig 87 Volkmann's ischaemic contracture. Flexion of the fingers unmarked by extension of the wrist.

forearm, and the amount of flexion at the elbow is diminished. Everything is done to restore the blood pressure to its normal level, and shock if present should be treated.

If the circulation has not recovered within the next hour the brachial artery should be explored at the bend of the elbow Division of the bicipital fascia releases the pent-up haematoma, and this may be sufficient to restore the circulation. If the brachial artery remains constricted it should be bathed with a $2\frac{1}{2}\%$ solution of papaverine sulphate The value of sympathetic block is debatable.

Myositis ossificans Again the aetiology is obscure At the end of three weeks when the collar and-cuff is discarded, either the elbow is quite stiff and shows no inclination to loosen, or there may be some movement which gradually gets less. Movement is restricted by muscle spasm, the tendon of the biceps stands out as a taut band, and there is tenderness in front of the joint. The radiograph shows a fluffy shadow with an indefinite outline similar to callus, in front of the elbow as though situated in the lower inch of the tendon of the brachialis anticus (figs. 88a, 88b)

Although the reason for the deposit of calcium salts is not known, it is certain that the condition is made worse by forced movements and even by passive movements. It is tempting to pump-handle a joint when the range is gradually diminishing Such treatment is foolish and leads to still greater stiffness.

The elbow should be rested in a collar-and-cuff until muscle spasm has disappeared. This may take months. At first it may not be possible to flex the elbow sufficiently to get the hand to the mouth, and the collar and-cuff is gradually tightened day by day until this essential position has been reached.

After prolonged rest the spasm disappears and movement returns, but there is often some permanent loss (fig 88c)

In the quiet stage, months after the injury when there is no longer any spasm or tenderness and the radiograph shows the mass to be clearly defined, it is worth while removing the bone if the patient has insufficient flexion for his needs. The operation however often fails to increase the range of movement. Operation in the early stages does nothing but harm.

Sometimes after a minor injury to the elbow there is permanent loss of movement, and although the radiograph does not show any calcified shadow the condition is possibly of the same nature as myositis ossificans.

Nerve injury In spite of the fact that the median nerve arches over the sharp anterior edge of the upper fragment serious harm does not often befall the nerve The liability should, however be borne in mind and the nerves should be examined if possible before reduction. Not infrequently there is some numbness of the index finger and some difficulty in making the tips of the thumb and index meet. These signs disappear within a few weeks. The ulnar and radial nerves are damaged less frequently

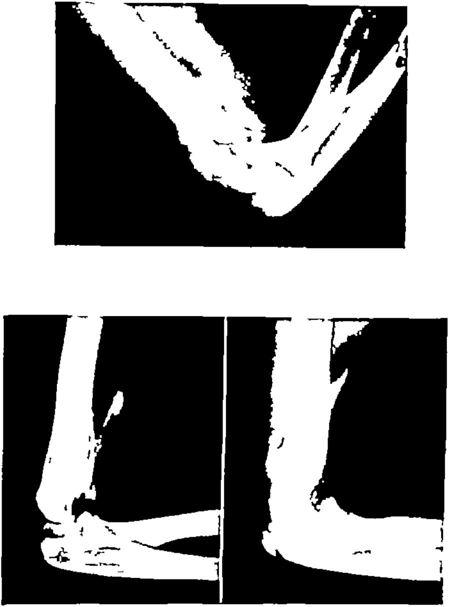
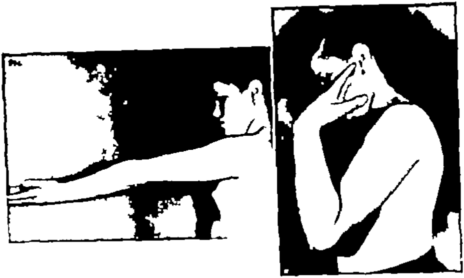


Fig 83 Myositis ossificans; *a* (*top*) soon after the fracture; *b* (*bottom*), three months and five years after the fracture; *c* (*opposite page*) range of movement five years after the fracture



SUPRACONDYLAR FRACTURE WITH FORWARD DISPLACEMENT

The situation of the fracture is the same as in the more common backward variety The fracture is usually incomplete and the lower fragment is tilted forwards.

Signs are milder than those of the backward fracture. The diagnosis is made on the lateral radiograph, which is not easy to read because normally the lower end of the diaphysis overlaps the epiphysis, especially in the young child and this gives an appearance of displacement. The only reliable test is to see where a line drawn down the front of the humerus cuts the curved lower border of the epiphysis; it should bisect it

The displacement is easily reduced by extending the elbow to the same amount as on the other side and securing the same degree of carrying angle

After reduction the arm is held extended in a plaster-of paris gutter splint for seven days, after which the elbow is freed and coaxed to flex Prognosis is good, and there are not any complications.

** FRACTURE OF THE LATERAL CONDYLE OF THE HUMERUS

This fracture, although not common, is of great importance because it is often missed, and because dire results follow if it is not reduced

As with other injuries of the elbow it is caused by a fall. The force travels up the forearm and shears off the lateral condyle. The fracture corresponds to a fracture of the capitellum in the adult.

The fracture is complete. The line starts about the middle of the articular surface and runs up and out to strike the epicondylar ridge half an inch above the epiphyseal line. The fragment includes part of the trochlea, the whole of the capitellum, and a small portion of the diaphysis. The displacement varies. There may be only a little lateral shift; more often the lower fragment rotates forwards and outwards. It is not easy to make out in the radiograph the exact orientation of the displaced fragment.

The radiograph is very often misleading. A large part of the fragment is cartilaginous and casts no shadow. In the front view the characteristic capitellar epiphysis is missing, and there is an abnormal irregular lump of bone to the outer side of the joint (fig. 89). In the lateral view the fragment may be hidden behind the humeral shaft, but is usually displaced anteriorly.

Clinically a young child after a fall has a swollen elbow which it will not move. It is not difficult to separate this injury from the other common injuries of the elbow. The patient is much too young for a fracture of the medial epicondyle; he can be coaxed to rotate his forearm so that the neck of the radius is intact; and a finger run down the back of the arm does not elicit tenderness so that a supracondylar fracture is unlikely. The child is rarely *over the age of four*.

Reduction

Slight lateral shift need not be reduced. But if the fragment has turned turtle it must be replaced right side up. Left unreduced it unites to the shaft with fibrous tissue and growth at the lateral half of the epiphyseal line ceases. This *gives rise to a valgus deformity at the elbow which increases until the growth* disc closes.

It is said that a fracture of the lateral condyle is only a complication of a dislocation, which in partly reducing itself displaces the fragment forwards, and it is claimed that if the surgeon redislocates the elbow and reduces the dislocation completely the fragment automatically falls back into its correct place (fig. 90). *The importance of accurate reduction is so great that it is justifiable* to operate when closed reduction fails, and while the child is under the anaesthetic it is safer to make sure of the reduction by doing it under direct vision (fig. 91).

A longitudinal incision is made over the bony lump which can be felt when the child is under the anaesthetic. The raw bony surface of the fragment *quickly comes into view and* by pressure of the thumb it can be rotated in and then back, when it falls naturally into position and disappears from view into the joint. Once replaced it shows no inclination to displace again. It need not be sewn back or secured in any way.

Splintage

Whether the fragment has been displaced or not, the elbow is slung in a collar and-cuff for three weeks.

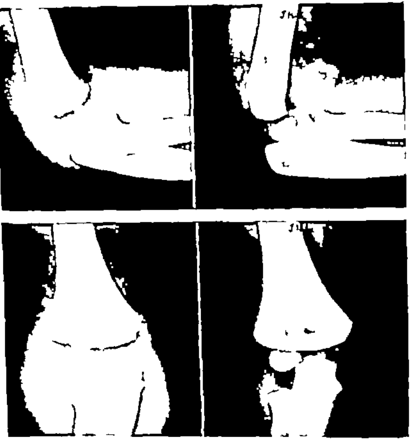
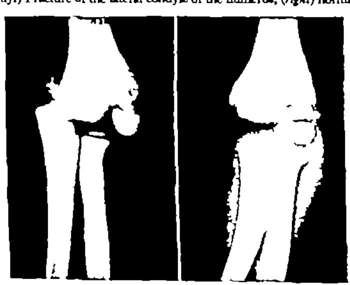


Fig 89 (*left*) Fracture of the lateral condyle of the humerus; (*right*) normal elbow



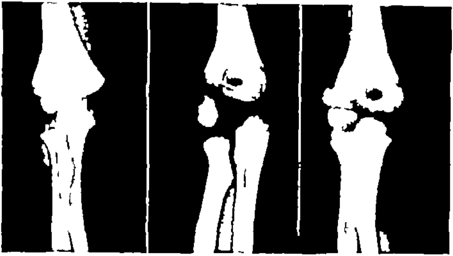


Fig 91 Fracture of the lateral condyle of the humerus; (*left*) normal elbow (*middle*) the fracture (*right*) after open reduction.

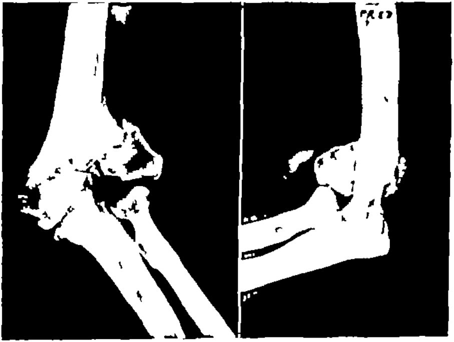


Fig 92. Old unreduced fracture of the lateral condyle

Protection

After the elbow is fixed no special protection is needed The child is allowed to regain movement by its own voluntary efforts.

Prognosis

Perfect recovery follows if the fracture has been reduced If the fracture is left unreduced, the elbow regains three quarters of its normal range but a cubitus valgus insidiously develops, owing to irregular growth at the epiphysial line (fig 92). This, apart from being unsightly does not give rise to any disability for many years then in middle life the patient gets an ulnar nerve palsy and the nerve has to be transposed to the front of the elbow

Usually union between the displaced fragment and the shaft is fibrous, the fibrous union as such is symptomless, but occasionally a pseudarthrosis forms and thus may be painful.

** FRACTURE OF THE NECK OF THE RADIUS

This is a common fracture in children under the age of four It follows a fall.

The fracture is often incomplete. The line runs transversely through the neck above the attachment of the biceps. The small upper fragment is tilted forwards and outwards (fig 93). Sometimes it is completely separate from the shaft.

After a fall a young child has a painful elbow The arm is not supported by the other hand. The contour of the elbow is normal Examination is resented, but it may be possible to discover that flexion and extension at the elbow are less resisted than rotation.

The only condition likely to cause confusion is the so-called *pulled elbow* This occurs at an earlier age and is due to traction on the arm. The child holds the arm immobile. Flexion and extension are free but rotation is not permitted A radiograph shows no bony injury If the forearm is suddenly supinated and pushed towards the elbow the child bellows but within a few minutes is using the arm normally again Should this manoeuvre not succeed nothing further should be done, for the child will recover full movement in a week or so The lesion is presumed to be a downward subluxation of the radius, which gets gripped by the orbicular ligament and is unable to move.

Reduction

A fracture of the neck of the radius needs reducing otherwise growth at the epiphysial line directs the head away from the articular surface of both humerus and ulna, and the head dislocates.

Closed reduction often fails and open operation must be resorted to. Through a small incision the muscles arising from the lateral epicondyle are

split. The head of the radius lies immediately beneath them, the articular surface facing the surgeon who with his thumb presses the head inwards and backwards. It snaps into position. Internal fixation is not required nor is it necessary to repair the capsule which has been divided in the approach to the bone (fig 94).

A warning must be given about excising the head of the radius in children. After excision the ulna grows at a faster rate than the radius This causes a subluxation of the lower radio-ulnar joint and an ugly wrist deformity Luckily it is never necessary to excise the head of the radius in a child for any injury

Splintage

After reduction the arm is slung in a collar and-cuff for three weeks. On removal of the collar and-cuff the child rapidly regains movement of its own accord.

** FRACTURE OF THE MEDIAL EPICONDYLE

This fracture is caused by a fall on the outstretched hand. The elbow is forcibly abducted and the apophysis to which the flexor muscles of the forearm are attached is avulsed. The apophysis only exists as a separate piece of bone between the ages of 10 and 17 and the fracture is limited to that age period. The apophysis with its attached muscles is displaced downwards and forwards. The joint is momentarily open, and the fragment may slip into the joint and get trapped. Fracture of the medial epicondyle may accompany a dislocation of the elbow and after reducing a dislocation an X ray should be taken lest the fragment has been entrapped.

After a fall a youth complains of a painful elbow The contour of the arm is normal. When the patient is asked to point with one finger to the painful spot he puts his finger on the medial epicondyle. There is swelling and tenderness over the medial side of the joint. Rotation is normal and some flexion and extension is possible. The fracture and its displacement are clearly seen when radiographs of the two elbows are compared (fig 95).

Reduction

Unless the displaced fragment is likely to cause an ugly lump on the medial side of the elbow or unless the fragment is trapped inside the joint the displacement may be neglected. When the fragment lies between the articular surfaces it must be extricated (fig 96). Sometimes one can induce the epicondyle to withdraw from the joint by abducting the elbow or by faradising the flexor muscles strongly while the child is anaesthetised. However recovery from the injury is quickest when the medial epicondyle is excised, and any excuse for doing this should be welcomed. The muscles quickly reattach themselves after the bony fragment has been excised. *Care must be taken to avoid damaging* the ulnar nerve at the operation.

Fig 93 Fracture of the neck of the radius.

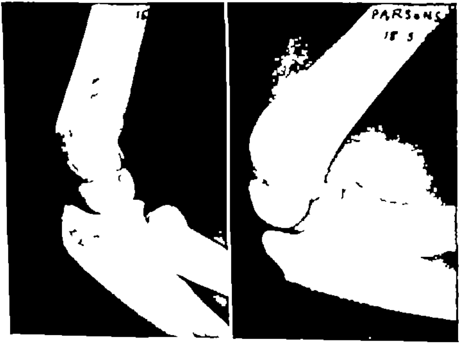


Fig 94 (*left*) Fracture of the neck of the radius;
(*right*) after open reduction.

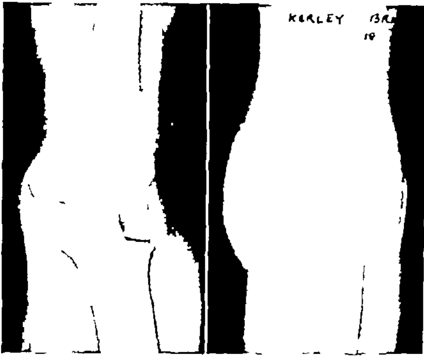


Fig. 95. (*right*) Fracture of the medial epicondyle; (*left*) normal

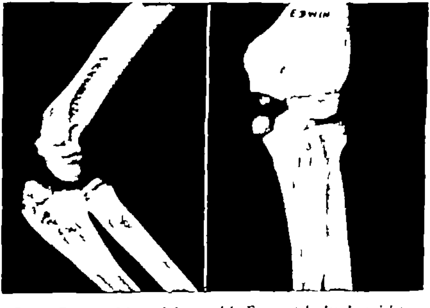


Fig 96 Fracture of the medial epicondyle Fragment displaced into joint.

Splintage

Whether the fragment is excised or not, the arm is slung in a collar and-cuff for three weeks.

Protection

At the end of three weeks when the collar and-cuff is discarded protection is not needed except that the child is advised to avoid activities that are likely to cause another fall, such as trick-cycling horse riding and skating The advice won t be taken.

Prognosis

Although the injury is trivial it is troublesome, and movement is a long time returning The parents should be warned of this and told not to expect full recovery for a year Recovery of function is full eventually although the union is sometimes fibrous and not bony

Complications

Ulnar nerve injury As one would expect, excessive abduction at the elbow—the force that causes the fracture—is apt to stretch and damage the ulnar nerve. Paralysis of the ulnar nerve is frequently associated with a fracture of the medial epicondyle. The nerve is never divided and therefore does not need suturing In the majority of cases the paresis is of short duration. In the few in which recovery is delayed it is worth while, at the end of six months, transposing the nerve to the front of the elbow

Persistent displacement of the fragment into the joint The displacement into the joint may be overlooked. If discovered later the fragment should be removed at open operation When the fragment is retained the elbow remains stiff for many months, although it is said that a satisfactory range of movement eventually returns.

•T SHAPED FRACTURE OF THE LOWER END OF THE HUMERUS

This is the adult equivalent of the child s supracondylar fracture, although it is caused in a different manner The patient falls striking the elbow on the ground. A vertical force passes up the humerus, and the shaft of the humerus breaks transversely just above the elbow and the lower fragment splits into two halves. The split may be incomplete, or complete with the two halves widely separated. The three fragments are displaced on one another in various directions (fig 97a).

The elbow is misshapen and the forearm is supported by the other hand. Movements are not permitted by the patient Bony points cannot be identified on account of the swelling Crepitus is felt in the course of handling The radiograph shows the gross displacement of the fragments

Reduction

The transverse fracture need not be reduced but exact anatomical reposition of the split fragments is desirable to restore congruity to the articular surfaces. This cannot be accomplished by a closed manipulation nor is it easily obtained at an operation. Moreover maintenance of reduction, obtained by whatever means, entails immobilising the elbow with consequent stiffness. Open operation and elaborate internal fixation produce pretty radiographic pictures but at the expense of a stiff joint. A more useful result is obtained if displacement is ignored and the congruity of the articular surfaces restored by early active movements.

Splintage

Accordingly the elbow is slung to the neck in a collar-and-cuff and active movements are encouraged from the start. At the end of a week a sling is substituted for the collar-and-cuff provided that the patient retains the ability to get his hand to his mouth. A sling facilitates purposive activity of the hand. The sling is retained for six weeks, the patient in the meantime being encouraged to use his hand and to move his elbow as much as possible.

The patient is warned not to expect any movement at the elbow unless he makes an effort to regain it. The range obtained is not nearly full but it is sufficient for most purposes (fig. 97b). Provided that movements are started early the ultimate range depends on the relationship of the two condyles. When they are widely apart and one is shifted on the other the range will be poor. When they are parallel and not separated, more movement can be expected. The displacement at the transverse fracture is immaterial and does not affect the amount of movement at the elbow.

** FRACTURE OF THE OLECRANON

There are two varieties: the direct and the indirect.

DIRECT FRACTURE

This is caused by a fall on the point of the elbow and is met with at all ages. There may be several lines of fracture but the fragments are not displaced (fig. 98). The olecranon region of the elbow is swollen and tender. Active extension of the elbow against resistance is possible, showing that the triceps is firmly anchored to bone.

The fracture may be complicated by a dislocation and by a fracture of the head of the radius.

The fracture requires neither reduction nor splintage. The patient may use a sling for a few days, at the end of which time the elbow rapidly returns to normal.

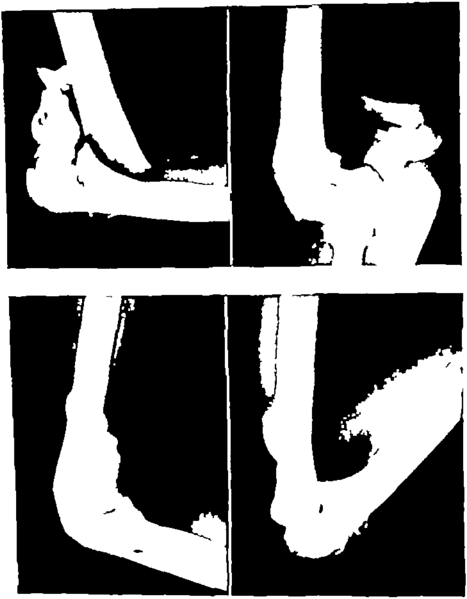


Fig 97 *a* (*top*) T-shaped fracture of the lower end of the humerus; *b* (*below*) eighteen months after showing range of movement

Fig 98 Fracture of the olecranon from direct injury
Elbow dislocated, neck of radius fractured

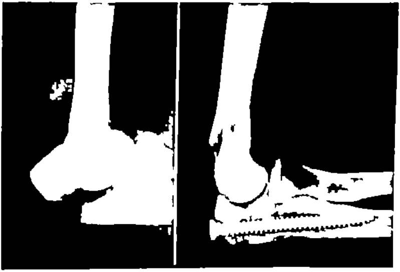


Fig 99. Fracture of the olecranon, from indirect injury Interval, one year

INDIRECT FRACTURE

This is a common injury in old people. It happens when the elbow is bent by an outside force while the extensors are contracting strongly. It occurs during a fall.

The fracture line is transverse and emerges about the middle of the trochlear notch. There may not be any displacement or the small upper fragment may be pulled up by the triceps (fig 99). Sometimes there is a third fragment or the upper part of the shaft of the ulnar may be comminuted.

The olecranon is swollen and tender. The position of greatest tenderness indicates the site of the fracture and the gap in the bone can be felt.

It is a mistake to look on this injury as a fracture. For purposes of treatment it is a rupture of the triceps muscle, and treatment depends on whether the rupture is complete or incomplete. It is important, therefore, to find out whether active extension of the elbow is possible. The patient, with elbow bent, rests the back of his wrist on the chest of the examiner who stands facing him. The patient is asked to extend his elbow and while he is trying the examiner palpates the triceps.

Reduction and splintage

If the rupture is incomplete and the patient retains some power of extension of the elbow against resistance the arm is supported in a sling for three weeks and active movements started at once.

If the rupture is complete and the patient has no power of extension the triceps must be reattached to the ulna. Two methods of doing this are in vogue. In the first the upper bony fragment is removed and the splayed-out triceps expansion sewn to the upper part of the shaft of the ulna by sutures passed through the bone. The elbow is rested afterwards until the triceps muscle is firmly reattached. In the alternative method the upper fragment is fixed to the shaft by means of a screw (fig 99). After this operation unrestricted movement of the elbow is safe from the start, and by the time the skin stitches are removed the patient can use his hand for ordinary purposes.

Complications

There may be an associated forward dislocation of the elbow. The dislocation is easily reduced, and the repair of the triceps is then carried out. After the operation the elbow is rested for a week in a sling: at the end of that time the joint is stable.

FRACTURE OF THE CAPITELLUM

Fracture of the capitellum in the adult corresponds to a fracture of the lateral condyle in the child. It is not a common injury. As usual with elbow injuries it follows a fall on the outstretched hand. It is an important fracture because

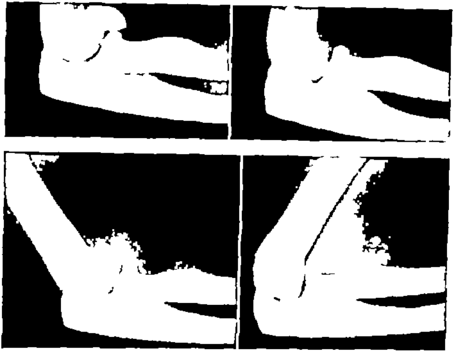


FIG 100 *a* (*top*) Fracture of the capitellum, *left* after open reduction, *right* *b* (*below*) two months later Range of movement.

failure to reduce results in severe disability The capitellum is sheared off and is then tilted forwards and displaced upwards. The fracture is clearly seen in a lateral radiograph (fig 100a).

The elbow is slightly swollen. The contour of the arm is normal. The elbow is held at a right angle but the arm is not supported. Tenderness is difficult to locate. Rotation is fair but only a few degrees of flexion are possible. To anyone familiar with the fracture the radiograph is unmistakable.

Reduction

Replacement of the fragment is essential otherwise the elbow remains stiff It may be possible to reduce by a closed manipulation but open reduction is easier and more certain. The elbow joint is opened on the lateral side and the fragment thumbed back into position.

Splintage

Once reduced the fragment remains in place, and fixation is not necessary The elbow is supported in a sling and active movements are started at once. A collar and-cuff should replace the sling if there is any difficulty in getting the

hand to the mouth Vigorous use of the arm is avoided for three months. Prognosis is excellent and a good range may be expected (fig 100b) The displaced fragment does not appear to undergo aseptic necrosis, which is remarkable.

FRACTURE OF THE HEAD OF THE RADIUS

This is a very common fracture in adults, and corresponds to a fracture of the neck of the radius in the child. The patient falls on the outstretched hand and a force passes up the forearm and impacts the head of the radius against the capitellum.

The contour of the arm is normal. There is tenderness localised to the site of the head of the radius. Some painless flexion and extension can be obtained but attempts at rotation cause pain and are restricted by muscle spasm There is very little swelling In fact the elbow looks normal and the fracture may easily be missed.

From the standpoint of treatment it is convenient to distinguish three types: the chisel, the marginal, and the comminuted.

* THE CHISEL FRACTURE

The fracture is incomplete and consists of a fissure running down from the centre of the articular surface for about half an inch (fig 101).

No reduction or splintage is necessary The patient may for the sake of comfort keep his arm in a sling for a few days. Movements are encouraged from the start.

** THE MARGINAL FRACTURE

A small wedge-shaped fragment is partly split off the outer margin of the head. The fragment is usually depressed but it may be tilted or it may be completely detached to form a loose body (fig 102)

If the fragment is loose inside the joint it must be removed This can be done through a right angled incision extending up along the epicondylar ridge and down towards the thumb The joint is opened, the loose fragment picked out and the skin closed. Sometimes a small flake is detached from the articular surface of the capitellum, and the articular surface should be inspected for damage and a fragment sought for if it is obvious that one has been detached.

If the fragment is not loose but is severely tilted it is better to excise the head of the radius.

** THE COMMINUTED FRACTURE

The head of the radius splits along several planes radiating from its centre and the fragments scatter (fig 103a)

The head of the radius should be excised forthwith. Occasionally operation is followed by the deposit of calcium in the capsule of the joint, and severe restriction of movement follows. The patient should therefore be carefully

watched when movement does not progressively increase after the operation. If movement gets less, all movement should be barred for a few days and then tentatively resumed. Forced movements are never permissible.

Prognosis

Convalescence after a fracture of the head of the radius is long. It is three months before the patient can turn a key without apprehension. Almost full rotation returns eventually but both flexion and extension often remain short by 20 degrees. The loss of extension is more obvious than the loss of flexion, although neither interferes with ordinary use of the arm. The prognosis after excision of the head is almost as good as after conservative treatment, so one need not hesitate to excise the head of radius in an adult (fig. 103b).

Fig. 101. Chisel fracture of the head of the radius.

Fig. 102. Marginal fracture of the head of the radius.

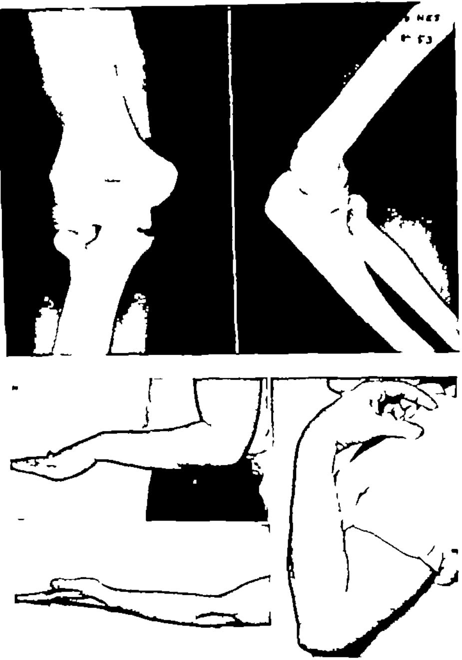


Fig. 103 *a* (*top*). Comminuted fracture of the head of the radius *b* (*below*) range of movement eleven months after excision of the head of the radius.

20

Fractures of the Forearm

• FRACTURE OF THE SHAFT OF THE ULNA

This is caused by a kick or a blow on the forearm, the exact site depending on the point of impact. The fracture is complete and the line of fracture transverse (fig 104). Displacement is minimal, there may be slight flexion of the upper fragment and radial bowing, but there is no shift, no overlap and no rotation deformity

The contour of the arm is normal and the limb is not supported. Local tenderness and swelling are elicited on passing a finger along the subcutaneous border of the ulna.

Splintage

Reduction is not required. In a fracture of the upper third the upper fragment tends to be flexed by the brachialis anticus so that the elbow is held flexed in a collar and-cuff for three weeks thereafter the arm is supported in a sling until the patient can use the hand without discomfort

In the lower third a plaster slab along the subcutaneous border of the bone usually makes the patient comfortable. Since no rotational stress falls on the ulna it is not necessary to prevent rotation and the wrist may be left free.

Protection

Nothing special is required At the end of six weeks it is safe for the patient to use his hand for anything but heavy manual work. One is often surprised that such a trivial fracture should take so long to repair and the amount of callus at the end of six weeks may be small (fig 23 page 54) A quicker result is obtained by plating the ulna, the arm is then ready for ordinary use in ten days.

Fig. 104. Fracture of the shaft of the ulna.

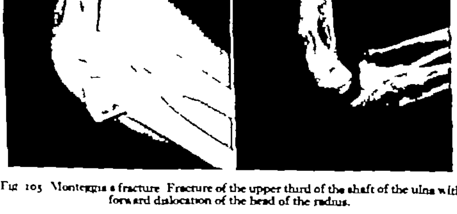


Fig. 105. Monteggia's fracture. Fracture of the upper third of the shaft of the ulna with forward dislocation of the head of the radius.

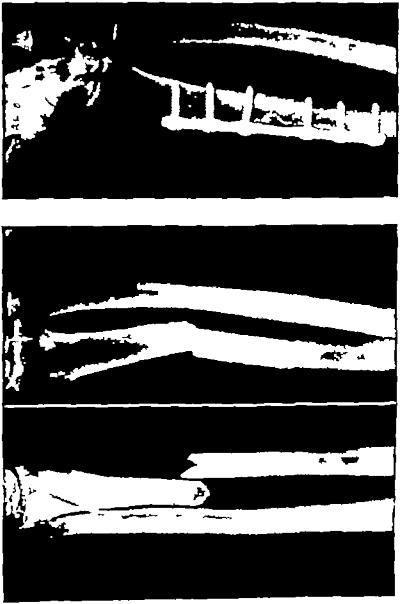


Fig. 106. *a* (*left*) Fracture of the shaft of the radius *b* (*right*), six months after being plated

• FRACTURE OF THE SHAFT OF THE ULNA WITH DISLOCATION OF THE HEAD OF THE RADIUS

This either follows a direct blow when the fracture is transverse or is caused by forced pronation of the forearm The patient, usually a child, falls on the outstretched hand and in falling rotates the trunk on the fixed forearm The ulna breaks in its upper third. The fragments may overlap but often only bow and the head of the radius is displaced forwards (fig 105) Although the displacement of the head of the radius shows clearly in a lateral radiograph, it is often overlooked. *With any fracture of the upper third of the ulna the elbow joint must be included in the lateral X-ray* Whenever there is overlap of a fracture of the shaft of the ulna there must of necessity be a fracture of the shaft of the radius or a dislocation of its head.

Reduction

Replacement of the dislocated head of the radius realigns the ulna. Under anaesthesia, while long-axis traction is applied to the flexed forearm the head of the radius is pressed back into position. During the manoeuvre the forearm should be in full supination because the fracture is caused by forcible pronation. Rarely the dislocation needs to be reduced openly because the head of the radius has passed through a buttonhole in the capsule.

Splintage

Flexion of the elbow with the forearm held in full supination prevents re dislocation of the head of the radius The fracture is treated as an uncomplicated fracture of the shaft of the ulna.

Some surgeons prefer to plate the ulna after reducing the dislocation so as to begin movements earlier

Should the dislocation have been overlooked it may prove impossible to reduce; if so the head of the radius should be excised in an adult. The head of the radius should also be excised when, as sometimes happens, the head passes backwards and radially instead of forwards. In a child the head of the radius must not be excised, and every endeavour should be made to reduce the dislocation

FRACTURE OF THE SHAFT OF THE RADIUS

This fracture which is only seen in adults is not common. It is caused by a direct blow on the forearm.

The fracture line is slightly oblique and the site depends on the point of impact. Displacement is variable there may be a slight lateral shift or complete overlap (fig 106a).

WITH OVERLAP

Reduction is difficult because neither distraction nor angulation (the two simple methods of reducing overlap) can be used on account of the intact ulna. Open reduction is necessary The fractured ends are exposed and reduced by a bone lever used as a shoe horn. Reduction once obtained is stable but since the bone is to hand the fracture may as well be plated (fig 106b) This enables external splintage to be dispensed with, at any rate for a fortnight during which time the patient regains active rotation. At the end of two weeks a plaster cast may be applied, although if the bone has been well plated external splintage can be dispensed with altogether

Unless overlap of the radius is reduced there will be loss of rotation because a shortened radius cannot rotate freely round an unshortened ulna. If overlap is reduced almost full rotation is restored provided that the lower fragment has been placed in correct axial alignment with the upper

WITHOUT OVERLAP

This fracture can be treated without operation. Nevertheless, many surgeons prefer to plate the fracture and dispense with external splints.

Splintage

Although reduction is not needed a PURE splint must be applied to prevent the bone ends rotating on one another when the rotator muscles of the forearm are in action. A plaster-of paris cast is applied extending from the middle of the arm above, down to and including the wrist. The elbow is held at a right angle, with the forearm in full supination if the fracture is high and in mid rotation if the fracture is low and the wrist is dorsiflexed. The plaster allows freedom of movement at the knuckle joints, and the thumb is also free.

Protection

The fracture unites in six weeks but rotational stress must be prevented until the fracture has consolidated The original plaster if loose or soft is replaced by a skin tight plaster of the same length The arm therefore remains in plaster for three months in all

FRACTURE OF THE SHAFT OF THE RADIUS WITH DISLOCATION OF THE LOWER RADIO ULNAR JOINT

This follows a fall on to the outstretched hand. In children the fracture is incomplete, and the only displacement is an anterior bow In adults the fracture is complete. There is backward tilt, a backward shift and some overlap and the upper end of the lower fragment inclines towards the ulna. In addition, either the lower end of the ulna is separated from both radius and carpus, or the ulna breaks transversely just above the radio-ulnar joint, the shaft being displaced in front and the radio-ulnar joint remaining normal (fig 107).

Fig 107 Fracture of the shaft of the radius with backward dislocation of the head of the ulna.

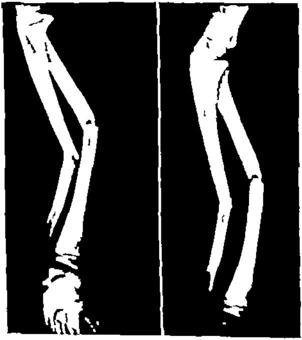


Fig 108. Fracture of the radius and ulna in a child. Angulation only

THE INCOMPLETE FRACTURE

The limb is not supported. The anterior bow of the forearm is noticeable. There is localised tenderness over the radius two or three inches up from the wrist and local tenderness over the lower end of the ulna.

Reduction

Hinging the lower fragment forwards reduces the radius with ease. The dislocation of the radio-ulnar joint is thereby automatically reduced but if there has been a fracture of the lower end of the ulna the overlap usually remains. It does not seem to matter and may be disregarded.

Splintage

A posterior plaster slab extending from the upper part of the forearm to just above the knuckle joints and holding the wrist slightly palmarflexed is sufficient in children. In adults it is wiser to control rotation for fear that the fracture has been made complete during reduction A plaster cast is applied from the middle of the arm to just above the knuckles. The elbow is at a right angle, the forearm in mid-rotation, and the wrist slightly palmarflexed. The knuckle joints are free and so is the thumb

Protection

At the end of six weeks the full length plaster is replaced by a short plaster extending from the upper part of the forearm to just above the knuckles. This holds the radius straight and prevents dorsiflexion of the wrist. It is worn for another six weeks.

Prognosis

Although a fracture of the ulna may not have been reduced the result is perfect.

THE COMPLETE FRACTURE

The limb is painful and has to be supported. The skin may be punctured on the front of the forearm rarely the end of the radius is still sticking through the skin when the patient is seen.

There is no need to perform a wound toilet operation because there is not any devitalised tissue to remove. The puncture hole is sealed with a dressing before reduction is attempted.

Reduction

Closed reduction often fails. After increasing the anterior bow an attempt is made to get the fragments to hitch and then the forearm is straightened. The displacement of the ulna is disregarded.

When closed reduction fails the radius is exposed and the fractured ends shoe horned into position by means of a bone lever

Splintage

PURE splintage is required. A plaster cast is applied to include the elbow and the wrist. If an open reduction has been done the bone is plated and then plastering is postponed until the patient has regained full rotation of the forearm.

Protection

To avoid rotational stress the PURE splint must be retained until the fracture is consolidated, i.e. twelve weeks in all.

* FRACTURE OF THE MIDDLE OF THE SHAFTS OF THE RADIUS AND ULNA IN A CHILD

This is a common fracture of childhood and follows a fall. The fracture lines are transverse or slightly oblique; and the fractures may be incomplete or complete. In the incomplete fracture the bones are in continuity but are angulated (greenstick fracture). In the complete fracture both bones are overlapped.

INCOMPLETE OR GREENSTICK FRACTURE

Bowing of the forearm is usually obvious. The forearm is not supported by the other hand. The radiograph shows that the bones are angulated (fig. 108)

Reduction

The fractures are readily realigned by straightening the forearm. If this is done gently the fractures remain incomplete.

Splintage

A circular plaster is applied from the middle of the arm to just above the knuckles. This holds the elbow at a right angle and the wrist slightly dorsiflexed and the forearm in mid rotation.

Protection

At the end of three weeks the complete plaster cast is replaced by a plaster strip moulded to the forearm. This is worn for another three weeks.

It not infrequently happens that the child falls again in several months time and breaks the forearm again in the same place. The mother should be warned about this. The warning will not prevent its occurrence but the doctor is absolved from blame for the second fracture, which the mother is otherwise apt to attribute to his faulty treatment of the first.

Fig 109. *a* (*left*), Fracture of the radius and ulna in a child. Overlap. *b* (*right*) six weeks after closed reduction.

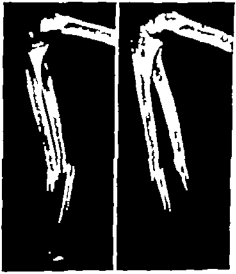


Fig 110*a*.

Fig. 110*b*

COMPLETE FRACTURE

Both bones are broken about the same level The fracture lines are transverse or slightly oblique. Both bones are overlapped and the lower fragments can be moved in any direction (fig 109a).

The patient supports the forearm and hugs it to his body The shape of the forearm is obviously abnormal Little time should be wasted in eliciting signs of a fracture it is kinder to X ray without examining further

Reduction

So long as angular and axial deformities are corrected end to-end apposition is unnecessary Subsequent growth soon smoothes out the callus and full rotation is restored (figs. 110a, 110b 110c).

Splintage

The elbow is flexed to a right angle and the forearm placed in supination or in mid rotation depending on whether the fracture of the radius is above or below the insertion of the pronator radii teres. One assistant applies traction by pulling directly on the hand or on two strips of Elastoplast stuck on the front and back of the hand Another assistant applies countertraction by pulling on the two ends of a flannel bandage looped round the arm just above the elbow The elbow is kept at a right angle. While traction and countertraction are still being exerted a circular plaster is applied from the middle of the arm to just above the knuckles. The plaster is well moulded round the wrist. When the plaster

Fig. 110c

Fig 110.

a Fracture of the radius and ulna in a child. Overlap.

b Six weeks later United with overlap

c Six years later (*left*) fractured arm, (*right*) other arm.

has set, and not before, the traction and countertraction are released. The flannel bandage is pulled away from the arm and the gap in the plaster made good. The plaster cast is then split from top to bottom *down to the skin* along the front of the arm and forearm. The hand swells on the next day but *so long as the colour of the hand is good and the patient has voluntary control of his fingers* no anxiety need be felt. All the same, the child should be kept in hospital until the swelling has started to subside, and should be seen daily until he has regained full movement of all finger joints.

Provided that the radiographs show good alignment in both views reduction is *satisfactory even though the bones are overlapped.*

Protection

PURE splintage needs to be continued until the fractures have consolidated. The full length plaster cast is therefore retained for six weeks.

** FRACTURE OF THE SHAFTS OF THE RADIUS AND ULNA IN AN ADULT

This fracture is common. It is not a domestic injury the usual cause being a car accident Both bones are broken about the middle of the shaft at the same level. The bone ends overlap and separate widely (fig 111a).

There is manifest deformity of the forearm, and the forearm is supported.

Reduction and splintage

The method used for children is not satisfactory It is difficult by closed manipulation to get the bones end on, and reduction if obtained can rarely be held. Trouble with the circulation of the hand is frequent, and the plaster cast has often to be sprung apart on this account and then it ceases to hold the fragments.

Fractures of both bones of the forearm are eminently suitable for plating Both bones are plated at the same operation (fig 111b). It is not difficult to obtain exact anatomical reduction. The forearm has not been crushed so that soft part damage is slight and the plating can be done at once.

Protection

After the operation the arm is left without any splint at any rate for the first two weeks. During this time the patient uses his hand as though he had not broken his arm and regains for himself full rotation. At the end of fourteen days if the surgeon is fearful lest active movement might loosen the screws a plaster cast is applied extending from the middle of the arm to just above the knuckles. The splint needs to be PURE i e. the splint must safeguard the fracture site from harmful stresses, particularly rotation, and therefore must contain two angles, one at the wrist and the other at the elbow With efficient plating plaster is not necessary

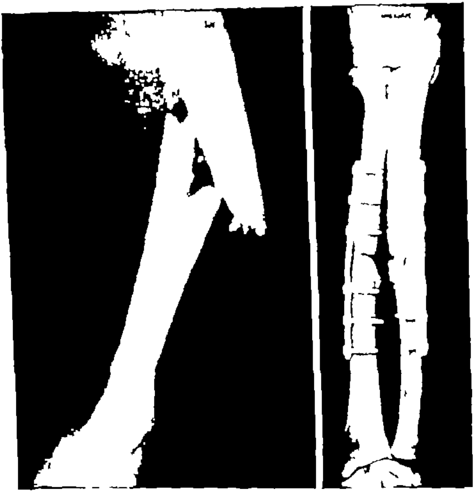


Fig. 111 *a* (*left*). Fracture of the radius and ulna in an adult. Overlap
b (*right*). Both bones plated, three months later

Sometimes one of the two plated bones is slow to unite, and if both bones have not consolidated in three months one should not hesitate to operate and to replace the plate with a bone graft

Complications of fractures of the shafts of the radius and ulna

Cross union In spite of popular belief this does not happen except after gun shot wounds.

Malunion Secondary malunion occurs insidiously under too loose a plaster This is especially common after the greenstick fracture of childhood. Both bones bow outwards and backwards. The deformity is ugly but disappears

with growth and the parents only need reassuring In the adult the fractures are difficult to hold reduced without interfering with the circulation. Open operation and plating get rid of the difficulty

Non-union. This is common It is due to allowing rotation of the forearm before the fractures are consolidated. The time table on page 34 shows that consolidation cannot be expected in an adult under three months. Splintage if external must be continued for that length of time.

Ischaemic paralysis This is rare but should always be borne in mind. The circulation of the hand is carefully watched and the patient should be kept under daily observation until finger movements are full.

FIG. 112 *a* (*top*), Fracture of the lower fourth of the radius and ulna. Complete. Before and after closed reduction. *b* (*below*) Six weeks later

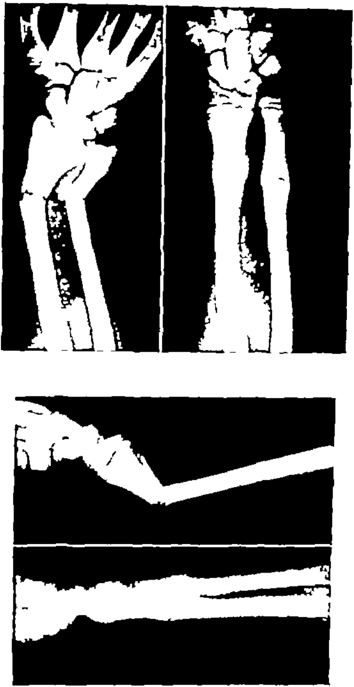


Fig. 113. *a* (*top*) Fracture of the lower fourth of the radius and ulna. Incomplete. Interval six weeks. *b* (*below*) Lateral view.

21

Fractures of the Lower End of the Radius

FRACTURE OF THE LOWER FOURTH OF THE RADIUS AND ULNA
FRACTURE-SEPARATION OF THE LOWER EPIPHYSIS OF THE RADIUS
Fracture of the styloid process of the radius
COLLES'S FRACTURE

*FRACTURE OF THE LOWER FOURTH OF THE RADIUS AND ULNA

This is a very common injury in young children. It follows a fall on the hand.

Both bones break transversely at the same level about one and a half inches up from the joint. The fractures may be complete; both lower fragments then ride up behind the shafts (fig 112a). More often the fractures are incomplete and there is forward and radial bowing (fig 113a) Sometimes only the radius breaks and the only radiographic sign may be buckling of the cortex on one side of the bone (fig 114)

Fig. 114 Fracture of the lower fourth of the radius and ulna. Incomplete No displacement. Buckling of one cortex only

Reduction

If there is not any overlap the alignment is corrected by hinging the lower fragment of the radius forwards (fig 113b) The ulna may be disregarded.

If there is overlap end to-end apposition of the radius can usually be obtained by increasing the angulation, getting the ends to hitch and then straightening (fig 112b). It matters little whether the bones are got end-on provided that the bones are straight because in the child the bone is rapidly moulded to its former shape and within a year or so it is impossible to detect either clinically or by radiography that the bones have ever been broken (figs. 115a, 115b).

Splintage

A posterior plaster slab extending from below the elbow to just above the knuckles and holding the wrist in slight palmarflexion is sufficient. Rotation may safely be allowed from the beginning Union is complete in three weeks and consolidation in six. It is wise to keep the plaster on for six weeks since the child is quite likely to fall again and refracture the bone.

*FRACTURE SEPARATION OF THE LOWER EPIPHYSIS OF THE RADIUS

This corresponds to the Colles s fracture of the adult and is met with in the early teens. The fracture passes partly through the metaphysis and partly through the epiphyseal line (figs. 116a, 116b) There may also be a fracture of the styloid process of the ulna or a separation of the ulnar epiphysis. The lower end of the radius is shifted and tilted radially and shifted and tilted backwards. The shaft of the ulna accompanies either the upper or the lower radial fragment.

The signs are those of a Colles s fracture, and reduction and splintage are the same (fig 117). There is little fear of redisplacement and the posterior plaster splint may safely be discarded after three weeks.

Prognosis

Interference with growth is rare Occasionally growth is retarded after an injury to the wrist and it is said that in these cases there has been not a fracture but a crushing of the growth disc, which would be invisible in a radiograph.

As soon as it is noticed that the ulna is growing at a faster rate than the radius the growth disc of the ulna should be operated upon and destroyed.

* FRACTURE OF THE STYLOID PROCESS OF THE RADIUS (CHAUFFEUR S FRACTURE)

This fracture used to be common among car drivers as the result of a backfire when using the starting handle An antero-posterior radiograph shows the fracture line clearly It starts from the centre of the articular surface and

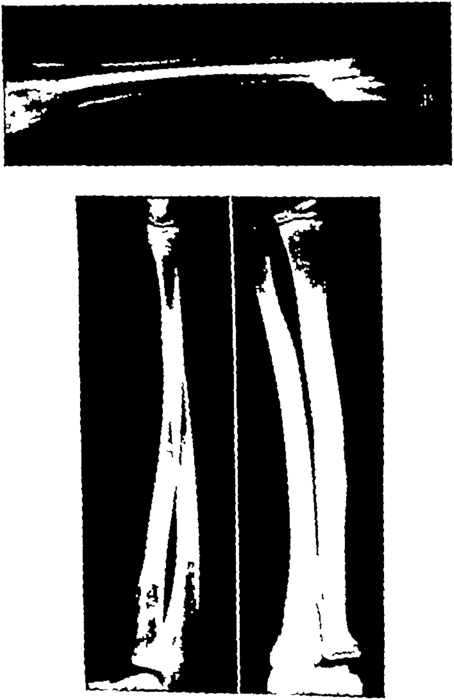


Fig. 115 *a* (*top*). Fracture of the lower fourth of the radius and ulna. United with overlap. *b* (*below*), two and a half years later showing remodelling.

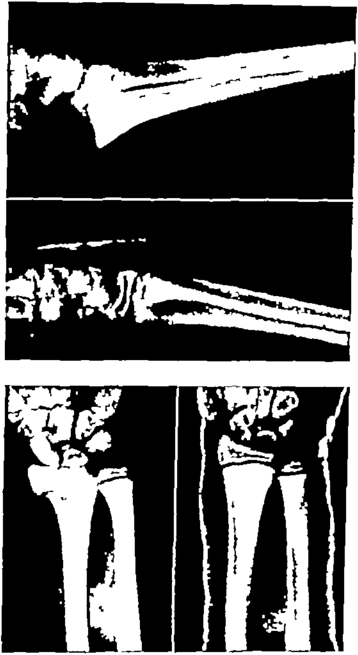


Fig 116 *a* (*top*) Fracture-separation of the lower end of the radius, before and after closed reduction. Lateral view. *b* (*bottom*) antero-posterior view

emerges from the lateral cortex about three quarters of an inch up the shaft (fig 118).

Usually there is not any displacement. Occasionally the triangular fragment and the hand with it is *shifted radially and displaced upwards.*

Signs may be few The history is helpful in making a diagnosis. There is rarely any deformity Tenderness can be located to a point on the lateral aspect of the radius about an inch up from the shaft

Treatment

When there has not been any displacement neither reduction nor splintage is needed. If the force of the blow has not displaced the fragment ordinary use of the hand need not be feared A sling is not necessary The patient is made to use his hand, and within ten days has apparently recovered. He should, however not attempt heavy manual work for three months.

When there has been displacement traction on the hand towards the ulnar

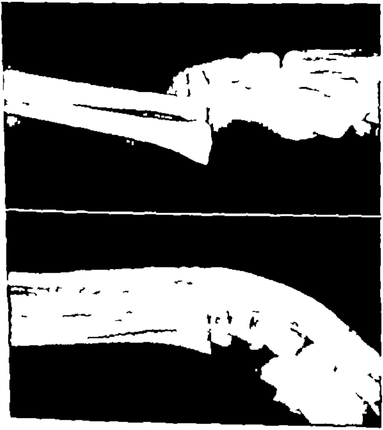


Fig 117 Fracture-separation of the lower end of the radius. Gross displacement Before and after closed reduction.

Fig 118 Chauffeur's fracture.

side easily reduces it. Then a plaster slab is applied to the radial side of the forearm and hand. The hand is deviated towards the ulnar side as much as possible.

At the end of six weeks the fracture has united and the plaster may be discarded.

An alternative method of treatment is to reduce the displacement at open operation and screw the fragment to the shaft. It has the merit of dispensing with plaster splintage, and the hand is restored to use more quickly

* COLLES S FRACTURE

It is convenient to include under this title several closely allied and clinically indistinguishable fractures of the lower end of the radius the classical Colles, the reversed Colles, and the T-shaped fracture.

CLASSICAL COLLES S FRACTURE

The patient, nearly always a woman past middle age, falls and hurts her wrist. In very young children its place is taken by fractures of the lower fourth of the forearm and in older children by a fracture-separation of the radial epiphysis. A Colles s fracture is uncommon in a man and usually of the T variety

The radius breaks transversely three quarters of an inch above the joint. The lower fragment is displaced in several ways: it may be shifted backwards and tilted backwards, shifted laterally and tilted laterally and the lower fragment may be supinated on the upper (figs. 119a, 119b) In addition to the fracture of the radius there is often a fracture of the tip of the styloid process of the ulna.

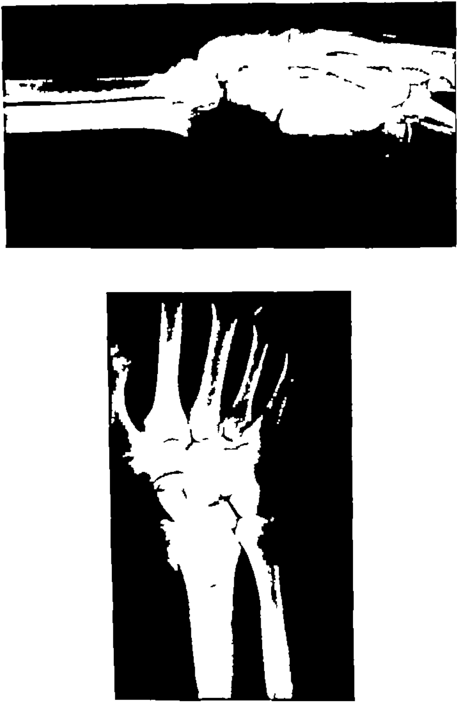


Fig. 119. Colles's fracture: a (*top*), lateral view showing backward shift and backward tilt; b (*below*), antero-posterior view showing radial shift and radial tilt.

Fig 120 Method of diagnosing a Colles's fracture Feeling for the radial pulse

Fig 121 Method of reducing Colles's fracture (*above*), getting rid of radial shift and radial tilt (*below*) getting rid of backward shift and backward tilt

Diagnosis

There may be nothing but the history of a fall and a swollen wrist on which to make the diagnosis. But if both wrists are palpated as though the radial pulses were being felt it will be found that the normal concavity on the front of the lower end of the radius is obliterated by a lump formed by a subperiosteal haematoma (fig 120). This manoeuvre also elicits localised tenderness over the lower end of the radius.

Displacement unless gross cannot be detected clinically A lateral view of the hand and forearm may suggest a backward shift but the important dis placement—backward tilt—cannot be detected clinically When there is a radial tilt the styloid processes are on the same level, but swelling may make it hard to feel the styloid processes distinctly

An antero-posterior radiograph shows a transverse fracture of the radius and, may be, a fracture of the ulnar styloid. If there has been gross displace ment the styloids are on the same level and the articular surface of the radius can be seen (fig 119b) Radial shift of the hand is not often present. A lateral radiograph shows comminution of the posterior cortex of the radius, and nearly always a backward tilt so that when the picture is horizontal, the articular sur face of the radius faces slightly upward instead of slightly downward as it does normally Backward shift of the lower fragment if present is plainly seen (fig 119a).

Dinner fork deformity though classical is not often seen and only occurs with a marked backward shift.

Reduction

Nearly every Colles s fracture needs reduction under anaesthesia because the cosmetic appearance of the wrist is important in the eyes of every patient. The reduction is done in two stages. First, with the patient s forearm horizontal and in mid rotation, the doctor grips the patient s forearm in one hand and with the other pulls the hand towards the ulnar side (fig 121) This corrects any lateral shift and lateral tilt, and also disimpacts the fragments. Then, with the patient s forearm vertical the doctor grasps the lower part of the forearm with both hands, placing the fingers in front just above the region of the break and the two thumbs behind over the lower fragment of the radius (fig 121). The thumbs press the lower fragment forwards and at the same time angulate it forwards. The pressure pronates the lower fragment at the same time. The doctor is able to feel the lower fragment of the radius glide forwards into posi tion, and if there is any doubt about the reduction the fragments may be dis-placed again with the fingers and replaced forwards with the thumbs.

Splintage

After reduction the hand is held slightly palmarflexed while a plaster slab six inches wide is moulded to the back and sides of the wrist and forearm. A piece of stockinette is threaded onto the forearm before the fracture is reduced. The

Fig. 122. Maintaining reduction while the plaster slab is setting

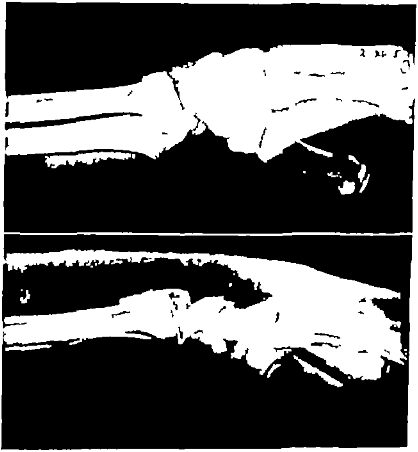


Fig. 123. Colles' fracture. Before and after reduction.

plaster slab extends from the upper part of the forearm to just above the knuckles. It is bound on firmly while the plaster is still wet and the secret is to apply the slab while it is still floppy While the plaster is setting the doctor maintains reduction by using the same grip as before (fig 122) After the plaster has set the original bandage is replaced by one less tight. When the patient comes round from the anaesthetic she should be shown that she is capable of flexing and extending her fingers fully

The doctor must see his patient on the next day for three reasons. to get reduction checked by a radiograph to see that the plaster is not too tight, and to begin treatment of the soft parts. As regards reduction, the important radiograph is the lateral and the articular surface of the radius should no longer be facing dorsally (fig 123)

The hand on the day after the reduction should be comfortable; if it is not there is something wrong If the patient cannot move her fingers or is complaining of pain or the skin is dusky in colour the splint is too tight. The bandage should be removed and the stockinette cut down from top to bottom where it shows on the front of the forearm and wrist. A loose bandage is then reapplied

The physiotherapist has two tasks. to make the patient use her hand, and to make the patient move to the full all the joints that are not splinted The patient attends the department daily until she has regained full voluntary con trol of the shoulder elbow and fingers. She should also be persuaded to rotate her forearm, which she can do in spite of the splint. A sling is disallowed after the first few days in order to encourage the patient to use her hand.

Protection

In order to avoid dorsiflexion stress at the site of the fracture the plaster splint is kept on for six weeks in all At the end of that time a few days attention from a physiotherapist restores the skin to normal, and active use of the hand completes the convalescence.

Prognosis

Pain about the head of the ulna may persist for some months and the radiograph often shows fibrous union of the styloid process. Ordinarily the symptoms abate and it is rare not to find at the end of a year perfect function even when reduction has been far from perfect. If the patient complains, it is of the appearance of the wrist and not of loss of function.

Complications

Painful shoulder The shoulder may remain stiff and painful for months after a Colles a fracture This may be because the shoulder was injured at the same time as the wrist or because the shoulder has been immobilised. Certain it is that if the patient can be made to move her shoulder on the day after the reduc tion the condition does not arise. The pain and stiffness last for months and finally disappear No treatment seems to shorten the period of disability

Fig 124. Zudeck's atrophy

Recurrent dislocation of the radio-ulnar joint Sometimes after a Colles's fracture the head of the ulna projects when pressure is exerted on the hand. If the recurring displacement annoys the patient the radio-ulnar joint should be fused and the ability to rotate restored by a pseudarthrosis of the ulna. Removal of the lower three quarters of an inch of the ulna is probably as good and convalescence after this operation is quicker

Malunion. It is rare for malunion to interfere with function, but the displacement of the hand causes an ugly deformity which distresses the patient. Secondary malunion is commoner than primary: after the displacement has been satisfactorily reduced it recurs insidiously because the plaster splint is not close fitting. Indeed in most cases the position when the plaster is finally removed is not as good as immediately after the reduction It is wise to confirm that all is well by taking a radiograph a week after the setting The patient

should always be warned that a Colles's fracture, however skilfully treated may leave behind a deformed wrist.

Non-union The fracture of the radius, being through cancellous bone, always unites by bone. The fracture through the ulnar styloid more often than not joins by fibrous tissue. The fibrous union accounts for the local tenderness and discomfort that persists for up to a year

Injury to nerves Occasionally there is a temporary partial interruption of the median nerve, and the patient has 'butterfingers' for a few weeks. Sometimes after a Colles's fracture a patient may reappear with the symptoms of a carpal tunnel syndrome.

Zudeck's trophic atrophy This rare unexplained condition may follow a simple Colles's fracture. There is severe pain in the hand, the skin is thin and cold and blue, and radiographs show patchy atrophy of the bones of the hand and carpus (fig 124) Often reduction has been incomplete but it is doubtful whether this is the cause of the condition. Indeed Zudeck's atrophy can follow an injury when the radiographs show no damage to bone.

As a rule recovery is spontaneous, but it may take up to two years. No treatment assists, except perhaps heat. Forced movements are harmful. Voluntary movements should be encouraged, and it is important to reassure the patient that ultimate recovery is certain.

Rupture of the tendon of the extensor longus pollicis This is the only common complication of a Colles's fracture that has been well treated. The tendon where it passes over the back of the lower end of the radius ruptures, apparently spontaneously six weeks or so after the accident. The tendon snaps painlessly and the patient suddenly discovers that she cannot extend the terminal joint of the thumb The power to extend the terminal phalanx can be restored by transplanting the distal end of the long extensor tendon into the short extensor tendon.

** REVERSED COLLES'S FRACTURE (SMITH'S FRACTURE)

This is an uncommon but important fracture which is hard to distinguish clinically from a classical Colles's fracture.

The term reversed Colles is misleading for the fracture line is different. In the lateral radiograph it runs obliquely: instead of being parallel to the articular surface it inclines forwards and upwards and the lower fragment slides forwards and upwards (figs. 125a, 125b).

Reduction

This is easy Traction on the hand reduces the upward displacement the lower fragment is then glided back into position in a manner similar to that used for the reduction of a classical Colles's except that the position of the doctor's fingers and thumbs are reversed.

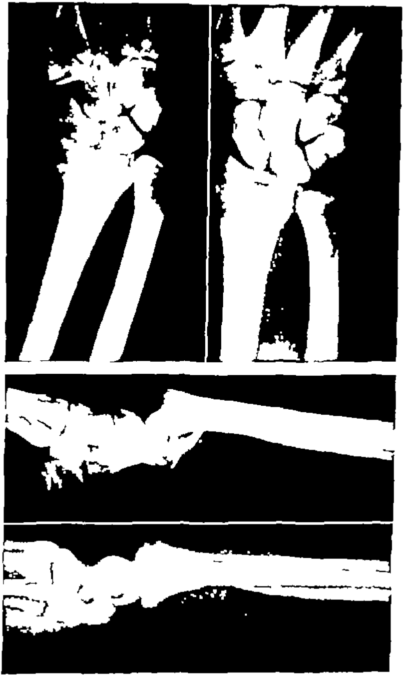


Fig 125 Reversed Colles's fracture: *a* (*top*) before and after closed reduction, *b* (*below*), lateral view

Splintage

Although reduction is easy maintenance of reduction is difficult on account of the obliquity of the fracture line. A plaster slab is applied to the front of the forearm and wrist extending from the upper third of the forearm to the proximal crease of the palm. The wrist is held in maximum dorsiflexion. As usual, the patient is taught to use his hand as soon as possible and to keep the shoulder and elbow joints free.

Protection

Special protection is not needed and the plaster can be discarded at the end of six weeks.

Prognosis

Secondary malunion is very common the lower fragment slipping forwards and upwards. It does not seem, however to interfere with function.

* T SHAPED FRACTURE OF THE LOWER END OF THE RADIUS

This happens, with a fall, when the butt of the hand rather than the palm hits the ground. A classical Colles s is uncommon in a man, and a man with the clinical signs of a Colles s fracture has usually sustained a T-shaped fracture of the lower end of the radius due to a longitudinal force ascending the radius.

The radiographs show the transverse fracture of the classical Colles s and in addition a longitudinal split into the middle of the joint (figs. 126a, 126b).

Neither backward shift nor backward tilt is common.

Treatment

Often there is no particular deformity to correct, and even when there is, the importance of restoring the normal concavity of the articular surface of the radius so that it fits the convexity of the semilunar and scaphoid makes immobilisation undesirable. Therefore, no attempt should be made to reduce the fracture and the wrist is not put into plaster A crepe bandage is wound round the wrist for comfort; and the patient is handed forthwith to the physiotherapist, who encourages him to move his wrist from the start. The final result is much better than if the fracture is treated as a classical Colles s with a posterior plaster splint.

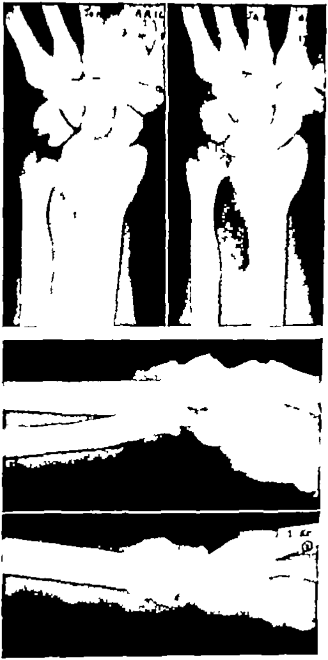


Fig 126 *a* (*top*) T-shaped fracture of the lower end of the radius into the wrist. Interval three months.
b (*below*) lateral view

22

Injuries of the Carpus

Sprain fractures
FRACTURE OF THE SCAPHOID
INTER-CARPAL DISLOCATIONS
Carpo-metacarpal dislocation

SPRAIN FRACTURES OF THE CARPUS

Dislocation of the wrist joint (i.e. the radio-carpal joint) does not occur except as an accompaniment of a fracture. An uncomplicated sprain of the wrist is so uncommon that the diagnosis should always be queried and the radiograph carefully scrutinised and repeated after a few days if local tenderness persists.

Occasionally as the result of a fall a flake of bone separates from the dorsum of the triquetral (figs. 127 128), or the tubercle of the scaphoid is detached. These sprain-fractures remain uncomfortable for a long period. There is no evidence that prolonged immobilisation cuts short the period of disability The patient should be encouraged to use his hand naturally

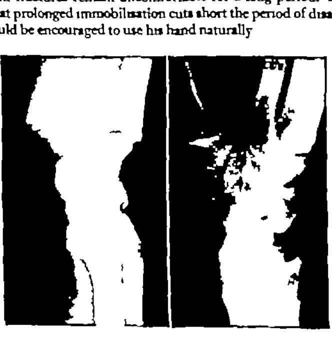


Fig. 127 Fracture of triquetral.

Fig. 128 Fracture of triquetral.

*** FRACTURE OF THE SCAPHOID

This fracture is common in young adults. It is caused by a fall on the hand or by a sudden jar. The wrist is dorsiflexed forcibly at the *intercarpal joint* and the scaphoid which forms part of both the proximal and distal row of carpal bones *is broken across its centre. The fracture line is transverse and passes across the* waist of the bone. The size of the proximal fragment varies; the larger it is, the better chance it has of retaining an adequate circulation. The proximal fragment is not displaced. The distal fragment although it may have been shifted backwards originally usually reduces itself.

A fracture of the scaphoid is frequently missed, for the clinical signs are few and the radiograph may be indecisive.

The wrist appears normal except for local tenderness over the scaphoid in the anatomical snuff-box, and pain on extremes of movement. Front, side and oblique X rays should be taken. The fracture appears as a crack, almost invisible, and may easily be overlooked (figs. 129, 130). If it seems likely from the clinical examination that the scaphoid has been broken and the radiograph is negative, another X ray should be taken in ten days' time. Slight rarefaction of the bone ends makes the fracture more obvious at the end of this period.

Splintage

Reduction is usually unnecessary as the distal fragment reduces itself with movement of the wrist. Since there are not any muscles attached to either fragment it is imperative to rely on external splintage to hold the fragments immobile i.e. this is one of those rare fractures that demand PURE splintage.

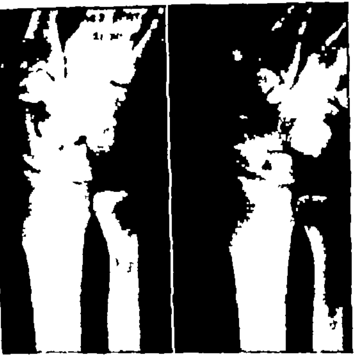


Fig 129. Fracture of scaphoid, proceeding to non-union (*left*) day of accident; (*right*) twenty months later

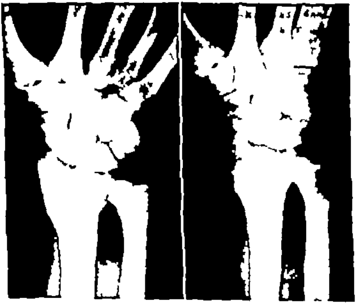


Fig 130. Fracture of scaphoid, proceeding to union. Anterior and oblique views (*see* fig 131).

Fig 128 Fracture of triquetral.

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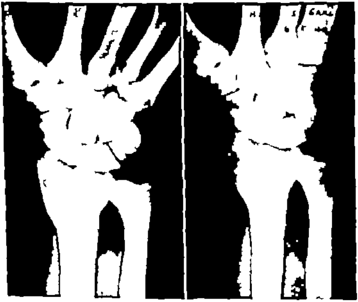

Fig. 130. Fracture of scaphoid, proceeding to union. Anterior and oblique views (*see* fig 131)

Fig 131
Fracture of scaphoid, patient of fig 130. Three months later

A circular plaster is applied extending from halfway up the forearm to just above the knuckles on the dorsum and to the proximal crease in the palm. Theoretically the wrist would be better straight but the plaster must incorporate two angles to prevent rotation and slight dorsiflexion supplies one angle (it also facilitates the use of the hand). The second angle is obtained by holding the thumb abducted at right angles to the palm. The plaster on the thumb reaches just short of the terminal joint (fig 132)

The plaster needs skilful application. After it has been put on and before it has set, the doctor grasps the hand (fig 133) so as to squeeze the front and back of the plaster This is done to prevent movements of the hand that would put a shearing stress on the line of the fracture. A plaster that allows any but the smallest amount of dorsiflexion and plantarflexion is useless. When the edge of the plaster gets soft, as it soon will if the patient uses his hand, it must be stiffened by the addition of more plaster or better still the whole of the plaster should be renewed.

The patient is encouraged to use his hand, which the position of the thumb and the freedom of the fingers enables him to do (fig 132).

Although a fracture of the scaphoid rarely needs reducing it is advisable to give an anaesthetic because the plaster can be moulded more closely if pain is abolished.

Protection

This is one of the few fractures that demand active protection during stage III of treatment while union is proceeding to consolidation. In most fractures of the upper limb sufficient protection is afforded by the avoidance of heavy

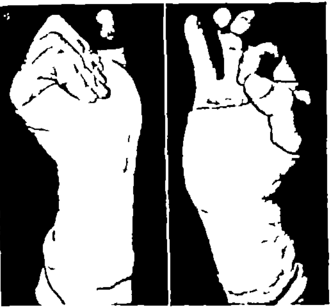

Fig 132 Plaster cast for fractured scaphoid, knuckle joints able to bend fully; thumb able to meet tip of index finger; plaster not extending beyond the transverse crease in the palm.

Fig 133 Plaster cast for fractured scaphoid, squeezing the plaster from before backwards while it is setting

Fig. 134. Fracture of scaphoid. Rarefaction of broken ends. Delayed union.

Fig. 135 Ununited fracture of the scaphoid. Gap between fragments. No arthritis of the wrist.

work. A united but not-consolidated scaphoid must in addition be protected from shearing stresses. It is necessary therefore to prevent movement at the intercarpal joint by the same kind of splint as was used for stage II In other words the original plaster is retained for three months from the date of the injury

Complications

Non-union. If treatment is properly carried out there is rarely any difficulty in getting bony repair and yet non union is more frequent with this fracture than with any other with the exception of a fracture of the neck of the femur There are several reasons for this: (1) Failure to realise that owing to the absence of internal splintage by muscles, external splintage must be relied on to keep the bone ends still, and that it must be PURE—prolonged, uninterrupted, rigid and extensive. (2) Failure to protect while the fracture is progressing from union to consolidation (3) Aseptic necrosis of the proximal fragment which if small may be totally deprived of its blood supply

The treatment of a fracture of the scaphoid that is still ununited at the end of three months depends on the radiographic findings.

If the fracture line is vacuolated (fig 134) bony repair can still occur Both stage II and stage III should be doubled. This means holding the intercarpal joint immobile for six months.

If there is a space between the two fragments and the two fragments have sclerosed margins (fig 135) bony repair will not occur until the sclerosed surfaces

have been freshened. This is done by drilling the bone. Often, in addition, in order to bridge the gap an autogenous bone peg is driven along the channel made by the drill. This is an exacting procedure, and should not be undertaken except by a surgeon experienced in the method. It may fail to secure bony union, and even if the fracture does unite wrist movement may still be painful. The patient is therefore often better advised to have nothing done and to put up with his slight disability

If the proximal fragment is very dense (fig 136) it is necrotic, and bony repair is unlikely The dead bone acts as a sequestrum and stimulates the synovial membrane of the joint to form granulation tissue. This persists as an intra articular scar and precludes painless movement. The whole of the scaphoid is best excised. If one elects to remove one fragment it should be the proximal. It is not uncommon for a surgeon after the operation to discover from radiographs that he has removed the wrong fragment or even the wrong carpal bone. Some surgeons prefer to remove the whole of the proximal row of carpal bones.

** INTER CARPAL DISLOCATIONS

Displacement backwards of the distal row of the carpal bones on the proximal row is met with in adults in the prime of life. There are two varieties of inter carpal dislocation, the second being a sequel of the first. In the first, as a result of a dorsiflexion force, the capitate—carrying with it the hand, the distal row of carpal bones, the triquetral and the distal half of a fractured scaphoid—is shifted backwards off the lunate. The lunate and the proximal half of the

Fig 136 Ununited fracture of the scaphoid. Proximal fragment small and dense No arthritis of the wrist

scaphoid remain in position. Sometimes the scaphoid is not fractured, instead, *its distal end is tilted back to fall into line with the distal row of carpal bones.* This variety of intercarpal dislocation is called *perilunate carpal dislocation*

At a second stage the capitate—carrying with it the hand, the distal row of carpal bones, the triquetral and the distal half of the scaphoid—springs forwards into position again, and in doing so impinges on the lunate rotating it forwards. This variety of intercarpal dislocation is called *dislocation of the lunate*

PERILUNATE CARPAL DISLOCATION

Gross damage to the wrist is obvious, yet the diagnosis may be missed because the signs are indefinite. The antero-posterior diameter of the wrist is increased *but this may be obscured by general swelling The* styloid processes are in their normal relationship On palpation of the radial pulse the normal concavity of the lower end of the radius can be felt. Tenderness cannot be localised. No movements of the wrist are permitted and the fingers will not move freely The radiograph, however is unmistakable to one familiar with the normal outlines of the capitate and lunate. In the lateral view the lunate is in its normal position and is facing in its proper direction, but the dome-shaped articular surface of the capitate is not in contact with the cup-shaped articular surface of the lunate (figs. 137 138); and the hand and carpus are in a plane posterior to the radius. In the antero-posterior view the lunate partly overlaps the capitate.

Treatment

Reduction is easy With one hand the doctor pulls and slowly flexes the wrist, while the thumb of the other hand presses backwards on the lunate.

After reduction the wrist is X rayed to see whether the scaphoid is fractured. *If there is not a fracture, splintage is not necessary and active* use of the wrist is encouraged. If there is a fracture, the intercarpal joint must be immobilised for three months. The fragments of an uncomplicated fracture of the scaphoid are not displaced but when the fracture is associated with an intercarpal dislocation the distal fragment is liable to be left behind when the carpus is replaced. Before the plaster is put on, therefore, firm pressure should be exerted on the fragment from the dorsum to shift it forwards.

Prognosis

Full recovery can be expected. If the diagnosis is missed and the dislocation is left unreduced wrist movements remain limited and painful. Useful function can be restored by excising the whole of the proximal row of the carpus. The rest of the carpus can then be replaced in its forward position. Excision of the lunate only or of the lunate and scaphoid is not satisfactory the whole row must go. A cock up splint is worn *for a few weeks and early voluntary movements* are encouraged.

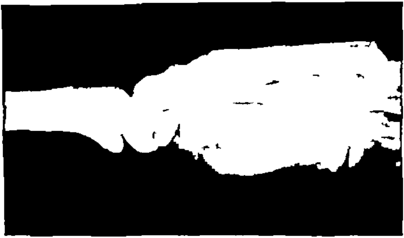

Fig 137 Intercarpal dislocation.

Fig 138 Intercarpal dislocation. Before and after open reduction.

DISLOCATION OF THE LUNATE

This is the second stage of an intercarpal dislocation. The distal row of carpal bones after being displaced dorsally spring back to their former position and in doing so impinge on the proximal row. The anterior radio-lunate ligament remaining intact and the posterior rupturing the lunate rotates forwards.

The styloids are in normal relationship. A lump may be felt in front of the wrist under the flexor tendons but this is usually obscured by the general swelling. Normally the lunate occupies a hollow that can be felt just below the radius on the back of the wrist in line with the middle finger. When the semilunar is dislocated this hollow is more pronounced than usual and is the site of maximum tenderness. The fingers are held semiflexed and will not straighten and movement at the wrist is small. The patient complains of numbness or pain over the distribution of the median nerve.

The rotation of the lunate is most obvious in the lateral radiograph (fig. 139). Its upper surface faces backwards and is no longer in contact with the articular surface of the radius, and its lower surface faces forwards and is no longer in contact with the capitate. The hand and carpus are in the same plane as the radius. In the front view the lunate instead of being quadrilateral in shape is triangular and partly overlaps the capitate (fig. 140).

Treatment

A manipulation similar to that used for a perilunate dislocation may succeed in reducing the lunate. The thumb is placed on the lunate and the bone is pressed backwards while the hand is pulled and flexed. In this method pressure has to be exerted through the median nerve, and many surgeons therefore prefer to reduce openly. A small incision is made on the palmar aspect over the lump the centre of which coincides with the distal crease on the front of the wrist. On retraction of the median nerve and the flexor tendons the lower articular surface of the lunate comes into view. Pressure from the thumb on the lunate bone while the hand is being pulled flicks it back into position. The operation is simple if the incision is correctly located.

The after treatment depends on whether the scaphoid has been broken. When it has, the intercarpal joint must be immobilised for three months. When it has not, splintage is not used and active movement is encouraged from the start. The irritation of the median nerve quickly passes off once the lunate bone has been replaced.

Occasionally the lunate bone although accurately reduced undergoes aseptic necrosis. The wrist then remains painful and may have to be arthrodesed.

CARPO METACARPAL DISLOCATIONS

OF THE THUMB. Unskilled boxers sometimes sustain this injury. The metacarpal is displaced backwards and radially.

Swelling at the base of the thumb makes one suspect a Bennett's fracture

but the thumb is immobile. The metacarpal is replaced by pulling on the thumb. It is, however, liable to slip out again and to retain it in position a close fitting plaster is applied around the carpus and the thumb. This is kept on for three weeks.

OF THE FINGERS. *This is an uncommon injury. All four joints are involved.* The bases of the metacarpals are displaced backwards and often sideways. The dislocations are only partial, they are in fact subluxations not dislocations.

Swelling on the dorsum of the hand may disguise the deformity and the diagnosis may be missed.

Soon after the accident reduction is easily accomplished by long axis traction, and once replaced the joints are stable. A posterior plaster slab, extending from the middle of the forearm to just above the knuckles, may be worn for a week because there are often associated fractures through the bases of the metacarpals and the splint makes the patient more comfortable. The wrist is held straight and the thumb is free. Active movements are started at once.

If undiagnosed the metacarpals quickly become set in their new position and reduction becomes difficult even at open operation. However, apart from the disfigurement of a bony projection on the back of the hand—not very conspicuous—there is no disability, so reduction is not imperative.

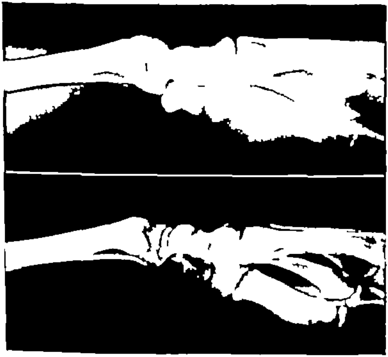

FIG. 139. Dislocation of the semilunar. Before and after open reduction.

Fig 140 Dislocation of semilunar Antero-posterior view Semilunar triangular rather than quadrilateral in shape.

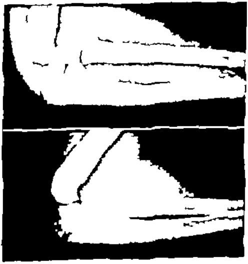

Fig 141 Forward dislocation of the head of the radius. Before and after reduction.

Injuries of the Radio-ulnar Joints

UPPER RADIO ULNAR JOINT

* FORWARD DISPLACEMENT OF THE HEAD OF THE RADIUS

The head of the radius passes forwards and lies in the hollow above the capitellum (fig 141) Usually the dislocation is accompanied by a fracture of the upper third of the ulna (see page 175)

The dislocation as a rule can be reduced by pressure backwards on the head of the radius while traction is being exerted on the flexed elbow but it recurs unless the forearm is held afterwards in full supination. Occasionally the orbicular ligament obstructs reduction and has to be divided at an open operation before the head will sink into its proper position.

Forward displacement of the head of the radius is apt to be overlooked by both doctor and radiologist. After any injury of the forearm the doctor should satisfy himself that the head of the radius is in its proper position.

Excision of the head of the radius is the best treatment for an unreduced dislocation in an adult. In a child the head of the radius must never be removed because excision is followed by a severe cubitus valgus. Instead, the dislocation is reduced at an open operation and the head is stabilised by a strip of fascia threaded round the neck of the radius and fixed to the subcutaneous border of the ulna. The same operation is used for a recurrent dislocation.

* DOWNWARD DISPLACEMENT OF THE HEAD OF THE RADIUS (PULLED ELBOW)

This happens to young children under the age of four The child, often without obvious injury complains of pain in the elbow and refuses to use the arm. The elbow is held immobile with the forearm pronated. There is sometimes tenderness over the head of the radius and rotation is resisted.

Even without treatment the child begins to use the arm again in a day or two. Sometimes one can restore painless movement forthwith by supinating fully and pushing the forearm towards the shoulder

LOWER RADIO ULNAR JOINT

** BACKWARD DISPLACEMENT OF THE HEAD OF THE ULNA

Slight backward subluxation of the head of the ulna is sometimes seen without any history of injury Often this is associated with a forward inclination of the lower end of the radius (Madelung s deformity). It is possible that Madelung s deformity is caused by a tearing away of the triangular fibro-cartilage from the ulna. Sometimes the subluxation recurs whenever pressure is put on the hand.

If the symptoms warrant, the radio-ulnar joint can be fused and the ability to rotate restored by making a false joint in the ulna just above the wrist.

FORWARD DISPLACEMENT OF THE HEAD OF THE ULNA

This, which is a permanent dislocation, is seen in a patient with an unreduced Colles s fracture. The disability is slight and treatment is not needed.

** CLICKING WRIST

A patient, usually a young woman, may complain of discomfort on rotation without any previous trauma. The lower radio-ulnar joint is tender and rotation is diminished and painful at the extremes. *The joint can often be felt to click.* The head of the ulna is prominent on the dorsum and there appears to be an undue antero-posterior mobility between the lower end of the radius and the ulna. It is possible that the triangular fibro-cartilage has been detached from the base of the ulnar styloid, and like a displaced semilunar cartilage in the knee is interfering with movement. When symptoms persist in spite of placebo physiotherapy the patient can sometimes be made comfortable by an excision of the triangular fibro-cartilage.

Fractures of the Metacarpals

** BENNETT'S FRACTURE

This happens to boxers and motorcyclists. The fracture line is oblique and runs from the ulnar border of the shaft about half an inch from the base upwards to cut the articular surface about its middle (fig 142). The proximal fragment remains *in situ*; the long distal fragment, comprising almost the whole of the metacarpal, is displaced radially and upwards.

Swelling at the base of the thumb obscures the displacement. But if the thumb is gently pulled crepitus is felt; this distinguishes the injury from two others that happen at this site—a dislocation and an impacted fracture.

Reduction

With long axis traction on the thumb and pressure over the base of the metacarpal the displacement is easily reduced.

Fig 142. Oblique fracture of the base of the first metacarpal into the joint. Bennett's fracture.

Splintage

Maintenance of reduction is difficult. Unless continuous traction is applied to the thumb the displacement recurs. The wrist is encased in a plaster cast in dorsiflexion (the wrist must be dorsiflexed *otherwise the plaster cast slides* down the arm and the pull becomes ineffective). The plaster is moulded closely to the base of the thumb while the thumb is being pulled. Adhesive-strapping tractions are then stuck on the thumb and the strappings tied to tapes, and the tapes to a loop of wire, the ends *of which are incorporated in the plaster*. The wire hoop must be inserted in the plaster in such a way that the thumb can touch the index finger—the standard position for immobilising a thumb. To render the traction efficient the tapes must be kept tight, and they need constant retying. The patient is encouraged *to move the other fingers*. The traction apparatus is persevered with for six weeks.

Despite constant supervision the apparatus often fails to do its job and a radiograph taken after three weeks shows that the displacement has recurred. Some surgeons prefer to hold reduction by a small pin or screw. Others despairing of being able to maintain reduction give up any attempt to reduce. Splintage is then unnecessary and the patient is able to start movements early. The immediate result from this method of treatment is excellent. This is not a laissez faire treatment; it is imperative that the patient regains for himself under the spur of a physiotherapist full movement at the carpo-metacarpal joint of the thumb.

Prognosis

Boxing is not safe for three months. Osteoarthritis is said to develop if the displacement is not corrected. Osteoarthritis of this joint is very common, but the patient rarely shows evidence of an old Bennett's fracture.

* TRANSVERSE FRACTURE OF THE BASE OF THE FIRST METACARPAL

This is seen as often as the Bennett's fracture. It is caused by hitting with the side of the fist. The bone breaks transversely about half an inch from the joint (fig. 143), *and the joint is not involved. The fragments are impacted.* There is an outward bow.

The base of the thumb is swollen and there is local tenderness. But the joint moves painlessly and there is no crepitus when the thumb is gently pulled upon.

Angulation should be corrected by pressing on the site of the fracture with the thumb while the head of the metacarpal is forcibly abducted. After correction the position is held with a plaster slab which holds the thumb in the *standard position, i.e.* that which allows it to touch the tip of the index finger. The plaster is worn for three weeks. Boxing should be barred for three months. Recovery is complete. If gross angulation is left uncorrected there is slight loss of thumb range, which however rarely inconveniences the patient.

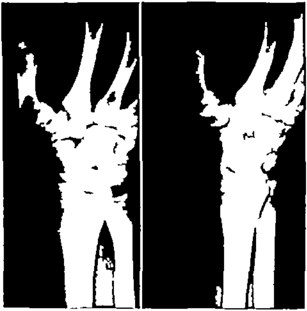

Fig. 143. Transverse fracture of the base of the first metacarpal. Joint not involved.

Fig. 144. Crushed hand.

*FRACTURE OF THE SHAFTS OF THE MIDDLE METACARPALS

One or several may be broken. The fracture line runs either transversely through the middle of the shaft or spirally along most of the length of the shaft (figs 145 146) The transverse fracture is caused by a direct blow on the back of the hand, the spiral by a twist. If transverse, there is backward bowing; if spiral slight overlap

The diagnosis is indicated by local tenderness. The radiograph may fail to reveal a fracture unless several views are taken.

Treatment

Backward angulation of a transverse fracture is easily corrected by pressure on the dorsum of the hand. The bowing is small and causes no disability if left, so that the displacement is often disregarded.

Overlap of a spiral fracture can only be held corrected by continuous traction, but as the slight amount of overlap gives rise to no disability and as fingers should not be immobilised unless absolutely necessary it is better to disregard the displacement.

Therefore in neither fracture is reduction attempted. Since reduction is not required, splintage is also unnecessary The patient is encouraged to use his hand, which he can often do in fair comfort within a week. Consolidation is not complete in a transverse fracture under three months, but the fracture line is not likely to be subjected to angulation or rotational stresses so that protection is not required.

Prognosis

Provided the fingers and thumb have been kept moving from the beginning recovery is perfect. Disability is due to limitation of finger movements from unnecessary and reprehensible immobilisation of the knuckle joints.

There is a general impression that these fractures should repair more quickly than they do The patient may be aware of crepitus for some days, and union in a transverse fracture is not to be expected under six weeks. Clinical repair is always in advance of what the radiograph suggests. Non union is rare, so that in any case where repair seems delayed patience is all that is required.

*FRACTURE OF THE NECK OF THE FIFTH METACARPAL

An isolated fracture of the neck of the fifth metacarpal as the result of a blow is a common injury The other metacarpals especially the first may also fracture in this way but not as often as the fifth. The fracture line runs transversely

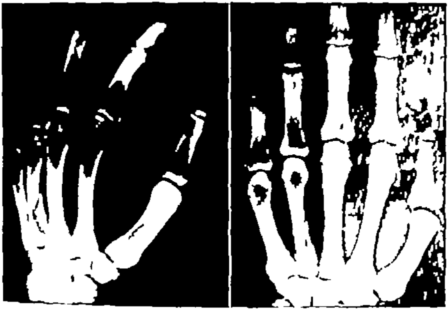

Fig 145 Spiral fracture of a metacarpal.

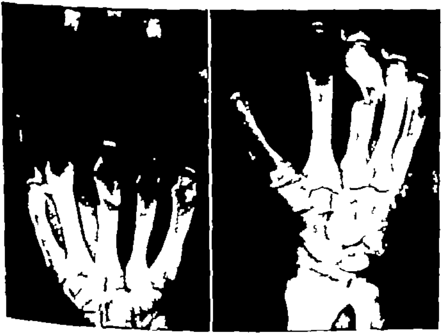

Fig. 146 Transverse fracture of a metacarpal

through the neck of the metacarpal about half an inch from the joint. There is backward bowing and also ulnar bowing (fig 147)

The presence of a fracture is suggested by local tenderness and swelling, and the diagnosis is confirmed by a radiograph.

Treatment

Ulnar deviation of the finger corrects the ulnar bow To correct the backward bow the knuckle joint and the proximal interphalangeal joint are first flexed to a right angle. Then the head of the proximal phalanx is pressed while counter pressure is exerted on the dorsum of the metacarpal just proximal to the site of the fracture. To maintain reduction a plaster strip one inch wide is moulded to the back of the hand and finger This extends from the wrist to the tip of the finger and holds the metacarpo-phalangeal and interphalangeal joints at right angles.

Since finger joints should never be immobilised if it can be avoided the period of splintage should be minimal. After ten days the plaster is removed and the patient is coaxed to move the finger The patient is ready for any except heavy work in three weeks.

Perfect function and an acceptable cosmetic result follow if the fracture is disregarded and the patient encouraged to use his hand. This shortens the period of disability

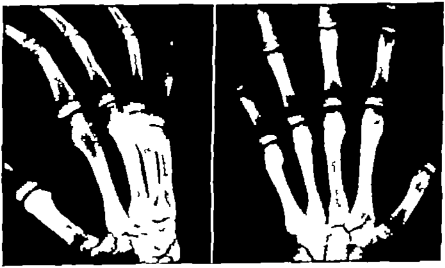

Fig. 147 Fracture of the neck of the fifth metacarpal.

25

Injuries of the Fingers

Dislocation of the metacarpo-phalangeal joint of the thumb
Dislocation of a terminal interphalangeal joint
Fracture of the proximal phalanx
Crush of the terminal phalanx
Sprain fracture of an interphalangeal joint
Fracture-subluxation of an interphalangeal joint
Mallet finger

** DISLOCATION OF THE METACARPO PHALANGEAL JOINT OF THE THUMB

This is not a common injury but is important owing to the difficulty of reduction. It is caused by hyperextension of the thumb The phalanx is displaced back on the metacarpal, and the head of the metacarpal passes forwards between the heads of the flexor brevis pollicis (fig 148)

An attempt at closed reduction is made under anaesthesia. While the knuckle joint is hyperextended and the interphalangeal joint flexed, the base of the phalanx is pushed forwards over the head of the metacarpal If closed reduction fails, as it often does, the joint is opened from the back. The capsule is pushed aside away from between the two bones and the phalanx shoe-horned forwards.

After reduction the joint is sometimes unstable, and it is therefore wise to stifle criticism by immobilising the joint for several weeks, either by adhesive strapping or by plaster-of paris.

* DISLOCATION OF A TERMINAL INTER-PHALANGEAL JOINT

This happens to cricketers and is caused by sudden hyperextension of the joint. The displacement may be partial and is likely to be overlooked. Traction applied to the terminal joint when it is flexed secures reduction. In an old un reduced dislocation the joint remains painful until it has been arthrodesed

** FRACTURE OF THE SHAFT OF THE PROXIMAL PHALANX

This is caused by direct injury The fracture runs transversely through the middle of the shaft, and the fragments bow forwards under the action of the intrinsic muscles (fig 150).

The deformity is easily corrected, but unless the knuckle joint is held flexed the forward angulation reappears. A plaster slab one inch wide, is therefore moulded to the back of the hand and finger It extends from just below the wrist to the finger tip and holds the knuckle joint and the proximal finger joint at a right angle. Union cannot be expected for six weeks, but as fingers should never be immobilised longer than necessary the splint is removed daily after *ten days and the finger actively straightened. After six weeks the splint is discarded.* Consolidation will not occur for three months from the time of the accident; and heavy work should not be attempted before then.

Mismanagement of this fracture is common. If forward bowing is not corrected there is serious interference with the flexor tendons. If lateral angulation is not corrected the finger crosses its neighbour when flexed and if the joints are immobilised for too long they become stiff

* CRUSH OF THE TERMINAL PHALANX

Although the phalanx may be split into several pieces the bone injury may be disregarded. Satisfactory repair is usual however widely separated the fragments are. The skin monopolizes treatment. If skin has been stripped off an immediate skin graft may be needed.

* SPRAIN FRACTURES

These are common in the fingers. The injury is caused by a lateral hinge which instead of tearing the ligament avulses bone from the base of the phalanx. The fragment is seen in the antero-posterior radiograph as a tiny triangular piece of bone (fig 151)

The principle of treatment is easy Ordinary movement at the joint is allowed while lateral hinge is prevented. This is done by the use of a miniature garter which binds the injured finger to its neighbour (fig 152) This gives the required protection and yet allows both fingers to flex and extend fully The finger remains painful for several weeks.

If the radiograph shows that the fragment has turned turtle, recovery is expedited by the removal of the loose fragment.

In time recovery is full, but it is best to warn the patient that the joint will remain uncomfortable for six months, and that there will be some permanent thickening

Fig 148 Dislocation of the metacarpo-phalangeal joint of the thumb

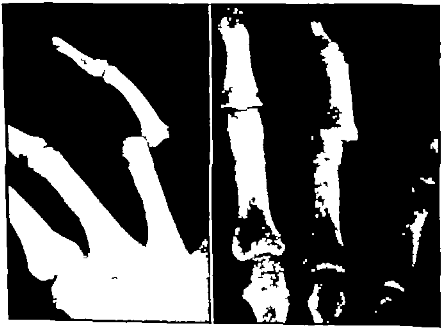

Fig 149 Interphalangeal dislocation.

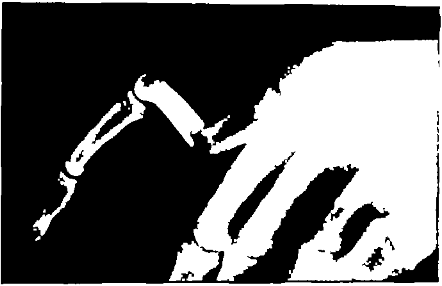

Fig 150. Fracture of the shaft of the first phalanx.

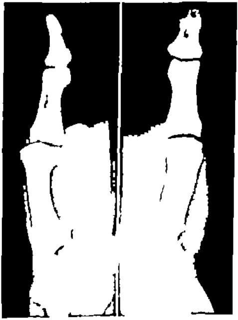

Fig 151 Sprain-fracture.

** FRACTURE SUBLUXATION OF AN INTERPHALANGEAL JOINT

This is a serious injury that baffles treatment. Following a blow on the end of the finger the condyle of one phalanx or the base of another is broken. The fracture line enters the joint and splits off part of the condyle. The fracture is accompanied by a subluxation Continuous traction on the finger realigns the bones and reduces the subluxation but considerable loss of movement results from the immobilisation. It is perhaps better to neglect the fracture and to begin active movements early Movement is more comfortable if the damaged finger is moored alongside its neighbour by means of a miniature garter (fig 152).

* MALLET FINGER

Sometimes after an injury the lateral radiograph shows a triangular fragment of bone detached from the base of the terminal phalanx (fig 153) This is usually an avulsion of the bone into which the extensor tendon is inserted.

If the fragment is held in position for six weeks it becomes firmly reattached A plaster slab is moulded to the back of the finger It extends from just below the knuckle to the tip of the finger and holds the proximal interphalangeal joint at a right angle and the terminal interphalangeal joint hyperextended. The splint is awkward and the proximal joint takes some time to regain movement when it is freed An equally good functional result is obtained if the terminal joint only is held extended by strapping The hand can then be used normally from the start. Whenever the strapping is renewed the joint must not be allowed to flex, for this would tear or stretch the repair tissue.

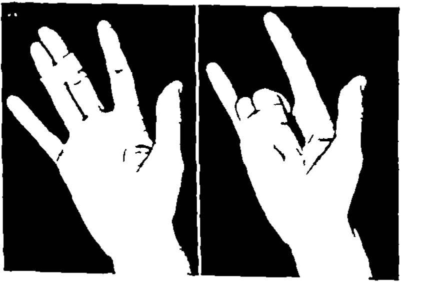

Fig. 152. Garter splint.

Fig 153 Fracture simulating mallet finger
a mallet finger would be bent.

Fig 154. Compression fracture of the pelvic ring

26

Fractures of the Pelvis

The pelvis forms a ring Solution of the continuity at one point does not impair the ring: displacement is slight and the intrapelvic structures are not damaged. Solution of continuity at two points disrupts the ring: displacement may be great and intrapelvic structures are liable to damage. Fractures of the pelvis are therefore divided into Disruptions of the pelvic ring and Isolated fractures of the pelvic bones.

DISRUPTIONS OF THE PELVIC RING

The patient is crushed or rolled on by a horse or a car wheel or falls from a height. The pelvis does not break at the point of impact and the bone injury is of little importance. The injury is serious on account of damage to intrapelvic structures, and shock is always severe. Shock, intrapelvic injury and fracture should be treated in that order

The patient cannot stand. He complains of pain in and around the pelvis, which is increased on moving and he feels as though he were falling to pieces. Compression of the pelvis causes pain Passive movements at the hip joints if attempted gently are painless. An exact diagnosis may not be possible until after a radiograph has been seen. However with a hinge fracture one foot is externally rotated and a gap may be felt at the symphysis, and with a vertical fracture one leg is short. There will probably be other injuries if the accident has been a fall from a height.

INTRAPELVIC INJURIES

Three are serious. haemorrhage, rupture of the urethra, and sciatic nerve palsy

RETROPERITONEAL HAEMORRHAGE

A major vessel is sometimes torn. If not immediately fatal this gives rise to a large retroperitoneal haematoma, which may cause death a few days later from *paralytic ileus* The gut is unharmed except in gunshot wounds.

RUPTURE OF THE URETHRA

From the point of view of treatment this is the important injury It is common in the compression type of fracture and rare in the others. The urethra is

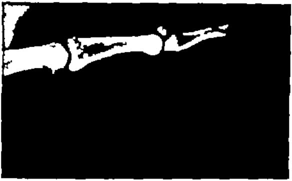

Fig 153 Fracture simulating mallet finger: a mallet finger would be bent.

Fig 154. Compression fracture of the pelvic ring

26

Fractures of the Pelvis

The pelvis forms a ring Solution of the continuity at one point does not impair the ring: displacement is slight and the intrapelvic structures are not damaged. Solution of continuity at two points disrupts the ring: displacement may be great and intrapelvic structures are liable to damage. Fractures of the pelvis are therefore divided into Disruptions of the pelvic ring and Isolated fractures of the pelvic bones.

DISRUPTIONS OF THE PELVIC RING

The patient is crushed, or rolled on by a horse or a car wheel, or falls from a height. The pelvis does not break at the point of impact and the bone injury is of little importance. The injury is serious on account of damage to intrapelvic structures, and shock is always severe. Shock, intrapelvic injury and fracture should be treated in that order

The patient cannot stand. He complains of pain in and around the pelvis, which is increased on moving and he feels as though he were falling to pieces. Compression of the pelvis causes pain Passive movements at the hip joints if attempted gently are painless. An exact diagnosis may not be possible until after a radiograph has been seen. However with a hinge fracture one foot is externally rotated and a gap may be felt at the symphysis, and with a vertical fracture one leg is short. There will probably be other injuries if the accident has been a fall from a height.

INTRAPELVIC INJURIES

Three are serious. haemorrhage, rupture of the urethra, and sciatic nerve palsy

RETROPERITONEAL HAEMORRHAGE

A major vessel is sometimes torn. If not immediately fatal this gives rise to a large retroperitoneal haematoma, which may cause death a few days later from *paralytic ileus* The gut is unharmed except in gunshot wounds.

RUPTURE OF THE URETHRA

From the point of view of treatment this is the important injury It is common in the compression type of fracture and rare in the others. The urethra is

usually torn above the urogenital triangle. The presence of blood at the meatus is pathognomonic but there may not be any. Exact information can only be obtained by passing a catheter and on the patient's arrival at hospital a catheter should be passed as soon as morphia has been given and a transfusion has been set up. If the catheter passes easily and clear urine is withdrawn injury to the bladder and urethra can be excluded.

Treatment

There are four principles of treatment: to bring the torn ends of the urethra into apposition, to divert the urinary stream, to drain extravasated urine, and to prevent a subsequent stricture.

While it is not essential to suture a torn urethra, the two ends must be brought into apposition. With a rupture above the urogenital triangle the neck of the bladder falls backwards and carries with it the upper part of the urethra, and the two ends of the urethra become widely separated. It is by no means easy to get the torn ends together. The damaged area cannot be reached at operation because it is above the pelvic floor and hidden by the bladder. The bladder is therefore opened and a metal sound is passed into the urethra from above. A second sound is passed from below and is coaxed to make contact with the first sound, and then to enter the upper end of the urethra as the first sound is gradually withdrawn in front of it. A catheter is fitted on the second sound when it appears in the bladder and it is then drawn back down the urethra. The catheter is left *in situ* for a few days and acts as a splint holding the torn ends of the urethra in contact.

To divert the urinary stream the bladder is drained suprapubically. Extravasation of urine is anticipated by draining the cave of Retzius.

Finally stricture of the urethra is prevented by repeated dilatation with sounds, which is begun as soon as the urinary catheter is discarded.

SCIATIC NERVE PALSY

This only happens with a vertical fracture. It is incomplete and usually recovers.

SKELETAL INJURY

This is of minor importance and should not receive attention until shock and intrapelvic injuries have been treated.

The ring is broken in two places and is unstable. Depending on the direction of the force three types of injury are recognised: compression fracture, hinge subluxation, and vertical fracture.

COMPRESSION FRACTURE

When the pelvis is squeezed, as when a person is squashed between a truck and a wall, the weaker anterior half of the ring gives way. The fracture lines run vertically through the rami of the pubis and the ischium *on both sides* (figs.

Fig 155 Compression fracture of the pelvic ring.

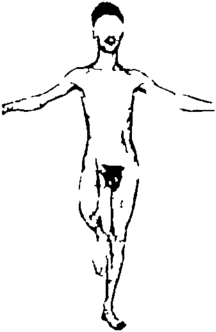

Fig 156. Compression fracture of the pelvic ring, patient of fig 154. Three weeks after the accident.

Fig 157 Hinge fracture of the pelvic ring

Fig 158. Vertical fracture of the pelvic ring

154, 155) This is the only type of fracture that is likely to damage the urethra.

Displacement is slight and reduction is not needed. Splintage is unnecessary because the fragments are splinted internally by muscles and protection is also unnecessary because the plane of the fractures does not coincide with the line of weight bearing. The patient is left free in bed, and active movements of the hips and spine are encouraged. He is allowed up as soon as he likes, two weeks in bed is ample. The patient is walking about before the fractures have united (fig 156).

** HINGE SUBLUXATION

Either the patient is run over or is rolled on by a horse. The force is concentrated on one anterior superior spine and pushes that ilium backwards and outwards. The symphysis separates and one sacro-iliac joint is hinged open. The injury to the sacro-iliac joint may not be visible in the radiograph, although usually the widening of the joint space is obvious (fig 157). Reduction occurs naturally if the patient lies on the other side and may be rendered more certain if the damaged half of the pelvis is firmly rotated forwards while the patient is under the anaesthetic. Reduction is easily held by a tight girth round the pelvis. Weight-bearing is not pushed for six weeks, but often the patient is up and about long before this.

** VERTICAL FRACTURE

This follows a fall from a height. There are vertical fractures through the pubis and ischium on one side, and on the same side a vertical split through the ilium just lateral to the sacro-iliac joint (fig 158). The damaged half of the pelvic ring is displaced upwards, it may be as much as an inch.

A strong pull on the leg reduces the upward shift, and reduction is maintained by skeletal traction through the tibia. Traction is continued for six weeks. Weight-bearing is not allowed for three months, although as soon as traction is discarded the patient is allowed up on crutches and taught to go through the motions of walking without taking weight.

Prognosis after disruptions of the pelvic ring

The initial mortality is high. If the patient does not die within the first twenty four hours from shock and haemorrhage, or within the first week from intra pelvic complications, the prognosis is good as regards survival. However the compression fracture is apt to leave behind a stricture of the urethra and in the hinge-subluxation the sacro-iliac joint remains painful for a time. In the vertical fracture if the displacement upwards is not corrected fully there is shortening of the leg but this is of no consequence. The partial lesion of the sciatic nerve which accompanies this injury takes some months to recover

ISOLATED FRACTURES OF THE PELVIC BONES

Stable fracture of the pelvic ring
Fracture of the ilium
Fracture of the rim of the acetabulum
Fracture of the floor of the acetabulum
Traction-separation of the pelvic apophyses
Fracture of the sacrum
Fracture of the coccyx

• STABLE FRACTURE OF THE PELVIC RING

The commonest injury to result from a crush of the pelvis is a unilateral vertical fracture of the ramus of the pubis and a similar fracture of the ischium on the same side (fig 159). Although these fractures involve the pelvic ring they do not disrupt it. And they are therefore classified and treated as isolated fractures of the pelvis.

Displacement is slight. Shock is not severe, and neither the urethra nor the sciatic nerve suffers damage.

No special treatment is needed. The patient is kept in bed until he can lift his leg off the bed. He is then got up and taught to take weight on the injured leg There is no danger of malunion or of non-union, and protection is not required.

• FRACTURE OF THE ILIUM

This is caused by a blow or by a fall on to a sharp point (fig 160). The fracture *is above the brim of the pelvis and is therefore free of intrapelvic complications.* The patient is often able to stand, and shock is slight. Tenderness and swelling indicate the site of the fracture.

Reduction is not needed even when the fragment is displaced. Splintage is done by the muscles. The patient remains in bed until he can stand in comfort. Thereafter he requires no further treatment.

• FRACTURE OF THE RIM OF THE ACETABULUM

This happens when the knee strikes the dashboard in a car smash. The same force may dislocate the hip and the two injuries are often seen together The head of the femur travelling backwards breaks a piece off the posterior rim of the acetabulum and pushes it backwards.

A glance at the foot shows that the attitude of the hip is not abnormal and also that there is no shortening The patient is unable to lift the leg off the couch, but gentle passive movements at the hip are tolerated. The radiograph shows a bony injury but does not often reveal the extent of the displacement.

The fragment can only be replaced at an open operation. It is retained in position by a screw Reduction is not, however essential unless the sciatic

Fig 159. Stable fracture of the pelvic ring Ring broken in one place only

Fig 160 Fracture of the ilium.

Fig 161 Fracture of the floor of the acetabulum. Interval one year

Fig. 162. (*left*) Fracture of the anterior inferior spine: (*right*) normal.

nerve has been damaged. Whether the fragment has been reduced or not, external splintage is not needed. *The patient is kept in bed until he has regained* muscular control of the hip joint, that is, until he can lift the leg off the bed and rotate it in the air He is then allowed up on two sticks and the sticks are withdrawn as soon as he can balance on the affected leg

Prognosis is good provided that the hip has not been dislocated. A fragment of bone may be broken off the head of the femur and get trapped in the joint; if so, the fragment must be removed.

• FRACTURE OF THE FLOOR OF THE ACETABULUM

This injury is caused by a fall onto the great trochanter and the head of the femur is forced against the floor of the acetabulum The head may remain in the socket after smashing the floor Or the force continuing, the head may penetrate the floor this is called a *central dislocation of the hip* (fig 161)

The position of the foot shows that the hip is lying in a normal attitude and that there is not any shortening of the leg The patient cannot lift his leg off the couch, and no movement of the hip can be elicited. Although the radiograph is characteristic the injury may be overlooked.

If the head is displaced into the pelvis it should be extricated by flexion and forcible adduction of the leg The displaced fragments of the acetabular floor cannot be replaced but this does not matter

The head when withdrawn from the pelvis is stable but the hip remains irritable and the patient is more comfortable if a Steinmann's pin is driven through the tibia and a 10 lb pull is applied The foot end of the bed is raised ten inches to supply counter-traction. The ordinary routine is carried out. The patient is kept in bed until he has regained muscular control of the hip He is then allowed up on sticks which are withdrawn when he can stand naturally on the damaged leg

The prognosis is good, and painless movement returns. If the head is not withdrawn from the pelvis the range of movement at the hip is much restricted although it increases with time.

• TRACTION SEPARATION OF THE PELVIC APOPHYSES

Three varieties occur none of them common. They are met with in school boys.

Separation of the anterior superior iliac spine

This happens when the hip is violently flexed against resistance, as when kicking a wet football

The boy falls to the ground and is unable to walk. There is tenderness over the anterior superior spine and active movement of the hip is painful

Separation of the anterior inferior iliac spine (fig 162)

This is commoner than the above, and is caused by the same kind of incident Tenderness is in Scarpa's triangle When seated the boy is unable to flex his hip further

Separation of the apophysis of the tuber ischii

This is the least common. It follows a sudden excessive action of the hamstrings. There is localised tenderness and pain on actively flexing the knee when lying on the abdomen.

In all varieties, although the apophysis is displaced there is no need to sew the fragment back; the gap fills in with bone. Treatment is not required. In a few weeks the boy is able to resume normal school life.

• FRACTURE OF THE SACRUM

This is rare. The fracture is often a crack without displacement and does not require treatment. The patient need not be in bed.

INJURY TO THE COCCYX

This is common in women who fall in the sitting position. They sustain one of two injuries: fracture of the coccyx or sprain of the sacro-coccygeal joint.

• FRACTURE OF THE COCCYX

The lower fragment is tilted forwards and the fracture can be diagnosed in a good lateral radiograph by the sharp angulation. There is localised tenderness and inability to sit in comfort.

The forward tilt should be corrected by the pressure of a finger in the rectum. Splintage is not required. For protection the patient carries about with her an air ring to prevent redisplacement of the lower fragment when she sits. The patient is comfortable in three months.

• SPRAIN OF THE SACRO-COCCYGEAL JOINT

Radiographs show no bony injury although there is localised tenderness and pain when the terminal part of the coccyx is moved.

This injury causes months of discomfort. Recovery takes as long as the similar injury at one of the finger joints. Treatment does not help. An air ring should be used to sit on. In stubborn cases it is worth while to operate and remove the mobile coccyx.

27

Injuries around the Hip Joint

DISLOCATION OF THE HIP
FRACTURES OF THE NECK OF THE FEMUR
SEPARATION OF THE UPPER EPIPHYSIS OF THE FEMUR
Fracture-separation of the lesser trochanter

• POSTERIOR DISLOCATION OF THE HIP

Dislocations of the hip used only to be seen after train smashes, nowadays they happen commonly in a motor-car accident. There are two varieties of dislocation. posterior (much the commoner) and anterior

In a car accident the knee hits the dashboard, and the force travelling up the thigh shoots the head of the femur out of the acetabulum (fig 163b). The head at first lies behind the acetabulum but immediately rides up onto the dorsum ilii.

The patient complains of severe pain and is unable to stand. A glance at the leg shows a characteristic attitude (fig 163a)· the thigh is flexed adducted and internally rotated. There are two inches of apparent shortening

Treatment

The position of the patient and the depth of anaesthesia are the two important factors in reduction. The patient should be placed on the floor and anaesthesia must be deep When the muscles are completely relaxed reduction is easy The doctor stands over the patient and flexes the knee and hip and then lifts the thigh and abducts. There is usually no doubt about reduction nevertheless an X ray should be taken to discover whether there has been a fracture as well.

The joint is liable to be irritable for a week or two therefore tibial skeletal traction is applied to the leg after the reduction. If the radiograph reveals the absence of any fracture this may tentatively be released and active movements begun. So long as there is a daily increase in the range and control of movement the hip is allowed freedom. If there is a fracture of the rim or if there is muscle spasm or if the range of movement begins to get less, traction is continued or reapplied as the case may be. As soon as the patient can lift his leg and rotate it in mid air weight bearing is permitted with two sticks, and the sticks are withdrawn when the patient is able to balance on the affected leg

In the absence of complications prognosis is good. The patient recovers almost a full range of movement.

Complications

Fracture of the rim of the acetabulum. This happens commonly If there is a fracture, traction is maintained for six weeks. If in addition there is a sciatic nerve palsy the nerve should be explored in case it has been impaled. The opportunity is then taken of reducing the fragment and fixing it with a screw

Fracture of the head of the femur The head of the femur may be broken instead of the rim of the acetabulum. If the radiograph after reduction shows a loose fragment inside the joint it must be removed.

Fracture of the shaft of the femur It is not uncommon for a fracture of the shaft of the femur to be associated with a dislocation of the hip And when this happens the dislocation is apt to be overlooked. It is a wise precaution to X ray the hip joint whenever a fracture of the thigh is suspected.

Sciatic nerve palsy This does not happen often. Recovery is usually full, but an irritative lesion may persist.

Myositis ossificans This only occurs when muscles have been torn. If the accident was not foreseen by the patient the muscles will not have been on their guard and will escape damage. If the crash was foreseen all the muscles of the body are taut and the force tears the hip muscles before displacing the head out of the socket. The history of the accident as told by the patient helps to decide whether this complication is likely

When the muscles have been torn it is some time before the patient chooses to move the hip It is tempting to try gentle force; this is folly But there is never any fear of inducing myositis ossificans by active movements, and so long as the patient will move the hip all is well. If movement becomes inhibited by muscle spasm, traction should be applied to the limb and exercises discontinued for the time being

It is not known why myositis ossificans develops in some cases of muscle injury and not in others. As soon as the radiograph reveals myositis ossificans all hopes of a fully mobile hip are at an end.

Aseptic necrosis of the head of the femur This is a most important complication. It is not known how common it is, possibly as many as one in three patients who dislocate their hip report a few years later with a stiff painful joint, and the radiograph shows a deformed sclerosed head of the femur Death of the head is only revealed by radiographs and then only several months after it has occurred. It is wise to X ray the hip every few months after the accident. If at any time the articular surface of the head becomes uneven and the head becomes unduly dense, in theory weight bearing should be disallowed until the density is restored to normal. This may mean crutches for several years. If weight bearing is allowed before the dead head is revitalised deformity is inevitable and this leads to a stiff painful hip However few patients can afford so long a period of convalescence.

It is uncertain whether aseptic necrosis can be averted by a period of immobility and relief from weight-bearing immediately after the accident. Some

Fig 163 Posterior dislocation of the hip: *a* (*above*) before and after reduction; *b* (*below*) radiograph.

Fig 164. *a* (*above*) Anterior dislocation of the hip: *b* (*below*), lateral view

figures suggest that early weight bearing makes no odds, others that aseptic necrosis is more common in patients who were not given a period of recumbency It is difficult to understand how immobilisation can affect the incidence of aseptic necrosis since the damage to the blood supply to the head must be done at the time of the accident. It is understandable that disallowing weight bearing while the head is soft might reduce the amount of ultimate deformity of the head.

Unreduced dislocation

A posterior dislocation of the hip if accompanied by a fracture of the shaft of the femur is often overlooked. Attempts at closed reduction are usually unsuccessful. Open reduction is apt to leave a stiff painful joint even if reduction is effected, and arthrodesis may later be advisable

• ANTERIOR DISLOCATION OF THE HIP

This injury is rare. It happens when an abducting force travels up the extended leg as in a fall from a height (fig 164)

The head of the femur lies in front of the acetabulum. There is severe pain and the patient cannot stand. The leg lies abducted and in extreme eversion. No movement can be obtained at the hip There is an inch of apparent lengthening of the leg

As with the posterior dislocation the patient is placed on the floor and deeply anaesthetised. The doctor stands over the patient, flexes the knee and hip and then adducts the thigh while pushing it down towards the floor It is said that reduction is sometimes impossible without open operation because the head button-holes the ligament of Bigelow

After reduction the patient remains in bed until he has regained control of the hip joint. He is then allowed up weight bearing In the absence of aseptic necrosis recovery is perfect. There are no other complications.

FRACTURES OF THE NECK OF THE FEMUR

Fractures of the neck of the femur are very common in old people, especially old women. There are three varieties: 1 *Transtrochanteric* This is the commonest. The fracture may be incomplete. The line of fracture runs obliquely through the two trochanters. Union by bone is certain. The fracture is never impacted. 2. *Adduction transcervical.* This is the most serious because union by bone is hard to achieve. The fracture is always complete. The line of fracture is just distal to the head, and is more vertical than horizontal. 3 *Abduction transcervical* This is the least common. Although the fracture is complete it is impacted. Union by bone is certain. The line of fracture is more horizontal than vertical and runs through the middle of the neck.

To distinguish these clinically is difficult. Every one is caused by a fall, although the break may occur while the patient is falling and may not be caused by impact with the ground. The patients are mostly old women, but young men may be victims. In children the neck may fracture close to the shaft; adult types of fracture are not seen.

** TRANSTROCHANTERIC FRACTURE OF THE NECK OF THE FEMUR

This is the commonest of the fractures of the neck. The fracture line runs obliquely along the intertrochanteric line. Often the small trochanter is separated off as a third fragment (fig 165) There may be no displacement in the front radiograph and considerable in the lateral (fig 166) Often there is angulation—an outward bow (fig 167) There may be comminution (fig 168a).

The patient is unable to walk. In bed the leg lies everted and is short. The shortening is greater than with the transcervical fracture and may be as much as an inch. This is the only helpful sign for distinguishing clinically between a transcervical fracture and a transtrochanteric fracture. The patient is unable to lift her leg off the couch and passive movements are painful.

Fig 165 Transtrochanteric fracture of the neck of the femur
Small trochanter separate

Fig 166 Transtrochanteric fracture of the neck of the femur No displacement. The anterior view is deceptive as regards the extent of the fracture.

Fig 167 Transtrochanteric fracture of the neck of the femur Marked angulation. Before and after correction by skeletal traction.

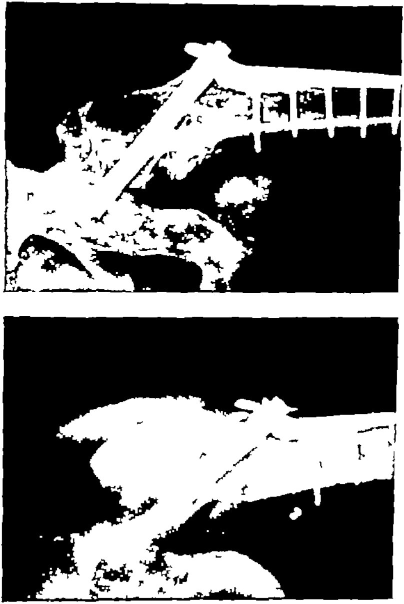

Fig. 168 *a* (*left*) Transtrochanteric fracture of the neck of the femur Comminuted. Fragments held together by a pin and plate. *b* (*right*) twelve months later

Reduction

Long axis traction on the leg combined with internal rotation reduces the main displacement (fig 167). The small trochanter may remain adrift but this is immaterial because the fragment reattaches itself to the shaft.

Splintage

PURE splintage is not required because there are muscles attached to both fragments and they are able to safeguard the fracture from harmful stresses. SIMPLE splintage is needed to hold reduction. The tendency to adduct can be countered by skeletal traction. A Steinmann's pin is passed transversely through the anterior half of the tibia one inch below the tubercle. A weight of 20 lb is needed and it must be maintained for twelve weeks. The skin holes may get sore before the end of this time period if so the pin is removed and skin traction substituted or the pin is reinserted an inch lower down the shaft of the tibia. Countertraction is provided by raising the foot end of the bed 20 inches.

Rotation is automatically controlled by the traction if the Steinmann's pin has been inserted correctly It should be horizontal when the patella is facing the ceiling

Protection

At the end of three months the traction is removed and the patient is allowed up The fracture has by this time joined but is not consolidated, and if the patient takes weight before the expiry of another three months the leg adducts at the fracture site and the patient is left with an inch of apparent shortening

To shorten the period of recumbency and to save hospital beds this fracture may alternatively be treated by internal fixation A combination of nail and plate is needed (fig 168b) The nail passes up the neck like a Smith Petersen's pin and the plate is screwed to the lateral aspect of the shaft of the femur The nail and plate may be combined, as in the Capener Neufeld plate or separate as in the McLaughlin plate. In the latter type the connecting screw may come undone or the union may break. After a successful plating the patient is able to get up as soon as he has regained muscular control of the joint. This is a great advantage.

Prognosis

The transtrochanteric fracture always unites with bone, but angulation is common on account of faulty reduction or faulty protection (fig 169).

**ADDUCTION TRANSCERVICAL FRACTURE OF THE NECK OF THE FEMUR

On account of the difficulty of getting union by bone this is the most serious of the fractures of the neck of the femur It happens mostly to old women and follows a trivial fall the patient tripping over a mat indoors and falling

The fracture line runs through the neck *just below the head. The fracture is* always complete and the line of fracture is more vertical than horizontal. The position of the central fragment is relatively unchanged, and the shaft is externally rotated, later the shaft adducts and rides up (figs. 170 171a)

The patient cannot stand as a rule. A glance at the foot shows that the leg is everted *and that there* is apparent shortening of half an inch (fig 172). The patient cannot lift her leg off the bed. These signs are sufficient for a diagnosis; palpation of the hip region is unnecessary and unhelpful. Shock is slight and this may deceive the doctor into taking too light a view of the injury

An X ray taken of necessity with a portable machine and often not very clear may be indecisive unless a comparison is made with the other hip Eversion is shown by the foreshortening of the neck and the prominence of the small trochanter Usually the line of the fracture can be made out.

Until recently the routine treatment was to immobilise the leg in a plaster of paris spica. This has been universally given up in favour of internal fixation ever since Smith-Petersen devised a metal splint—a three flanged nail—that would prevent rotation as well as overlap and angulation.

It is usually recommended that reduction should not be attempted for several days to allow the patient to recover from shock and to see whether she is viable. But shock is almost non-existent, and every patient is viable if treated. It is often convenient for the surgeon to delay operating for a few days, but it is better for the patient to be transferred straightaway to a hospital where there are facilities, namely a fracture table and an X ray apparatus in the theatre, and for the reduction to be done within twenty four hours. There is no need to tell the patient that she is to undergo an operation. It is sufficient to explain that the fracture must be set and that the setting can only be done under anaesthesia. This is accepted as a natural course of events and the worry associated with the anticipation of an operation is eliminated.

The advantages of early operation are that everything is completed under *one anaesthetic, the patient is made comfortable* quickly and the general health is interfered with less because the patient quickly moves herself about in bed. It is possible for a patient to feel the same as she did two days previously although in the interval she has broken her leg travelled in an ambulance to a hospital, and undergone an operation.

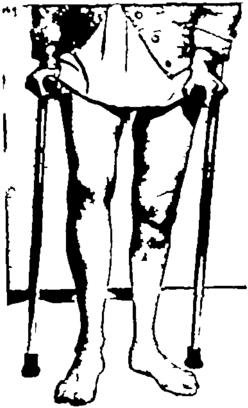

Fig 169. Transtrochanteric fracture of the neck of the femur Not treated. Leg short and externally rotated.

Fig 170. Adduction type of transcervical fracture of the neck of the femur Successful pinning

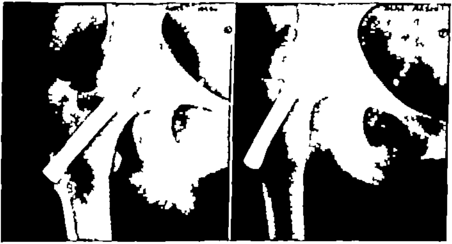

Fig. 171 *a* (*top*) Adduction type of transcervical fracture of the neck of the femur. *b* (*below*) good reduction and well-placed pin. Yet aseptic necrosis ensued. Interval: two and a half years.

Reduction

It is easy under anaesthesia to reduce overlap by a pull, and eversion by turning the leg in. The pull is best applied with the hip flexed to a right angle. Reduction must be accurate to enable the nail to be inserted into the very centre of the head. The importance of accurate reduction needs stressing, and the surgeon must be prepared to make more than one attempt.

If it has been decided to postpone operation for a few days skeletal traction is applied to the leg: this renders the patient fairly comfortable and often reduces the fracture. If fixation is to follow immediately, the reduction is done in the theatre and maintained during the operation by tying both legs under traction to the foot pieces of a fracture table. The patient's legs are held extended, slightly abducted and rotated in. To make sure that reduction is perfect a lateral as well as an antero-posterior radiograph is essential.

Splintage

Since there are not any muscles attached to the capital fragment there is nothing to prevent the fragments from moving constantly on one another. PURE splintage is therefore required. This is obtained by internal fixation with a Smith Petersen's triflanged nail, which is driven up the neck of the femur through a small incision over the outer side of the thigh (figs. 170, 171b).

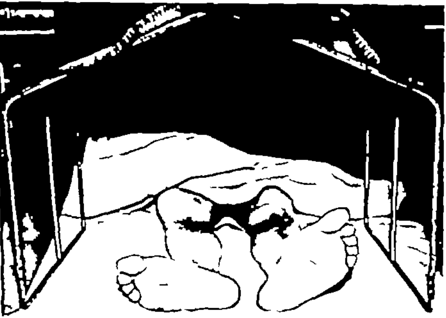

Fig. 172. Fracture of the neck of the femur showing eversion of the foot.

The head fragment is small and its greatest diameter is not more than one inch, so that to secure an adequate hold on the proximal fragment the nail must be plumb in the centre of the head. A rigid wire is therefore first inserted, and reinserted if need be several times until it penetrates the centre of the head. The guide should appear exactly to bisect the circumference of the head in two X rays taken at right angles to one another The position of the nail in the neck is of secondary importance, although the nearer it lies to the lower border of the neck in the antero-posterior radiograph the better because the bone in the centre of the neck is cancellous and does not grip firmly (fig 173a). A nail lying alongside the cortex is much more firmly held (fig 173b).

If the guide is driven on into the acetabulum it serves the additional purpose of preventing the head fragment from tilting during the insertion of the nail.

When the surgeon is satisfied with the position of the guide wire the nail is threaded over it and driven in. It should reach up to but not penetrate the articular cartilage. It is better to go too far than not far enough.

The difficulty of the operation is to insert the guide wire accurately Many pieces of apparatus have been devised to ensure this, not one of which has so far found universal acceptance. It is not proposed to describe any particular method because the surgeon should see the method in use before trying it himself: descriptions are inadequate.

The position of the guide wire and the final position of the nail are checked by front and lateral radiographs obtained during the course of the operation. Good radiographic facilities are essential

No external splintage is used On the day after the operation the patient is encouraged to move the hip and knee joints while the doctor or the physiotherapist supports the weight of the leg The nurse may safely roll the patient over on to her side to attend to her back. It is far better for the patient to regain movements during the first few days because with delay there is increasing stiffness of both knee and hip

Protection

The patient is allowed up as soon as she can lift her leg off the bed and rotate it in mid air Although on crutches she is taught to go through the normal action of walking In theory weight should not be taken on the leg for six months from the time of the injury but the patients who do well weight bear of their own accord long before this.

An X ray should be taken once a month to watch the behaviour of the nail, and to detect the first signs of aseptic necrosis. A well placed nail that begins to back out of the head almost always signifies death of the head.

Prognosis

This depends to a large extent on the skill with which the nailing has been performed. The nail is well tolerated (fig 174) The complications of the operation are few The operation does not induce shock. Mental deterioration

Fig. 173. *a* (*top*) Paget's disease showing lines of force in the neck of the femur. *b* (*below*) Adduction type of transcervical fracture of the neck of the femur. Pin well-placed according to the lines of force.

Fig 174. Transcervical fracture of the neck of the femur
Pinned sixteen years ago.

pneumonia and urinary infection which were common with the plaster metho
of fixation are no longer to be feared. Age is no bar to operation.

The immediate results of the nailing operation are magnificent. Unfortun
ately many later turn out failures. The patient is up on crutches or she may b
weight-bearing when there is a gradual or a sudden onset of pain in the hip
and a radiograph shows some unpleasant and unexpected complication.

Failure is caused by: *The nail smashing its way out of the head.* This is due t
faulty technique and the surgeon is to blame. The nail has not been driven int
the centre of the head and therefore has not had sufficient purchase on th
capital fragment. When the radiograph suggests that the hold on the head i
precarious the patient is kept in bed longer and vigorous movements are dis
couraged.

The nail slipping out Some nails do not shift, others are gradually extrude
from the bone. The head of the nail should always be buried in the cortex o
the shaft.

The nail penetrating the joint This happens when the head fragment ha
softened as a result of aseptic necrosis and weight bearing is being permitted.
It cannot occur without absorption of the bone at the fracture line—an indica
tion that bony repair is not taking place.

Sometimes at the operation the nail is driven too far If central, the nail does
little harm even though it appears to project a quarter of an inch beyond the
bony outline of the head.

Aseptic necrosis of the head This cause of failure is usually beyond the surgeon's control. Whether the head is going to die is decided in most cases at the time of the injury It is possible however that when the capital fragment is not firmly immobilised by the nail continual movement at the fracture line might tip the balance against the survival of the head when the blood supply was precarious. Monthly X rays should be taken to watch for the early signs of aseptic necrosis. The earliest clue is an increase in the density of the head as compared with the neck. Later irregular indentations appear on the circumference of the head in the radiograph (fig 171b) Once aseptic necrosis appears all hope of obtaining a painless mobile joint has gone: it may be better to perform an arthroplasty forthwith.

UNUNITED FRACTURE OF THE NECK OF THE FEMUR

Non-union is common after an adduction transcervical fracture. The causes are many:

Faulty reduction The capital fragment looks outwards and the neck fragment looks forwards, but this forward bow would not in itself cause non-union if it did not render it difficult for the nail to obtain a satisfactory purchase on the head.

Faulty splintage Internal fixation offers the only hopeful method of splinting the fragments. But even so, the head fragment is small and it is not possible to get the nail to penetrate more than one inch, and even that small distance is only possible if the nail lies exactly in the centre of the head, and it is difficult to place the nail in the centre of the head unless reduction has been perfect. If the nail is not absolutely central the odds are against a successful result. The probability is that either the nail will break out of the head (which can be seen in a radiograph) or the head fragment will begin moving on the nail (a condition that cannot be seen in a radiograph) and there will be a continual shearing stress at the site of the fracture.

Faulty protection. The line of fracture being more or less vertical a shearing force acts on it whenever the patient stands. For this reason refracture is liable to happen up to the time that the fracture is consolidated, i e., six months from the time of the accident.

Aseptic necrosis of the head One cannot tell early whether the vascular supply to the head has been cut off, and aseptic necrosis can only be diagnosed with certainty some time later when deformity of the head has taken place. However if an X ray taken three months after the accident shows that the head is denser than the neck, the head is probably dead. For practical purposes if aseptic necrosis appears before the fracture is united it can be assumed that union will not occur

Symptoms

When there is pain it should be tracked down to its source. Pain may be caused by·

Poor mechanics An ununited fracture is not necessarily painful. But shortening, eversion of the leg and the dipping gait all add to the fatigue of walking

Strain on the capsule The joint capsule is being continually stretched, first by the riding up of the shaft at each step and second from the inability of the joint to place itself in the position of minimal effort. In the normal position of weight bearing the muscles have little work to do because the weight is transmitted directly through the centre of the joint. With an ununited fracture of the neck of the femur the hip is adducted and flexed. Great muscular effort is required to support the weight of the body in this position, one has only to stand oneself with the hip slightly flexed to realise how fatiguing this is. It is no wonder that the muscles tire and the ligaments have to bear the brunt of the force.

Arthritis of the hip joint This is usually associated with, and caused by aseptic necrosis of the head of the femur

Treatment

Before selecting any form of treatment the factors contributing to the symptoms must be identified—whether it be the shortening and the eversion, or the deformity of the hip or painful movement. Then, the radiograph is inspected to see whether the head is dead or alive, how much of the neck has been absorbed how high the shaft has risen and the width of the joint space

It is only worth while attempting to get bony union when the head is alive, when there is no arthritis and no hip deformity and when there is sufficient amount of neck not otherwise. Such favourable conditions exist rarely Traction is applied for some weeks to bring the shaft down as far as possible. Then the fractured surfaces are exposed and freshened and the fracture nailed. As a result of the operation a head previously alive may die.

When there is little hope of getting bony union operation should not be done if the symptoms are due simply to poor mechanics. A slight raising of the heel of the shoe and a stick will enable the patient to get about. It is seldom worth while ordering a weight relieving caliper the relief obtained from preventing telescoping of the shaft is overshadowed by the discomfort caused by the bucket.

When the patient s complaints are thought to be due to adduction-flexion deformity an osteotomy often helps. Two types of osteotomy are in vogue: the McMurray and the high cuneiform. In the McMurray osteotomy the shaft is divided parallel to the neck just above the small trochanter and the shaft is displaced medially In the high cuneiform osteotomy a large wedge of bone is removed from the same site. Both operations besides correcting deformity cause the upper fragment to adduct and thus changes the line of the fracture

from the vertical to the horizontal As a result telescoping is abolished and bony repair of the fracture may occur

When pain on movement is the chief complaint, the head of the femur should be excised After this operation the hip is unstable and the patient sways his trunk over to the side when walking The dipping gait can be masked to a large extent by the patient if he uses a rigid stick Many operations have been devised to get rid of the instability of the joint. At present, replacement of the head of the femur with a prosthesis (a procedure first popularised by Judet) is on trial.

*ABDUCTION TRANSCERVICAL FRACTURE OF THE NECK OF THE FEMUR

This is the least common of the fractures of the neck of the femur which is unfortunate because it is the easiest to treat. The line of fracture runs almost horizontally through the middle of the neck. The fracture is always impacted with slight angulation and in the radiograph the fractured surfaces overlap in the lateral half where the fracture line may be invisible and gape slightly in the medial half (fig 175). The abduction angulation is not easy to detect unless comparison is made with the other hip the under surface of the neck is straight on the fractured side, whereas it is slightly curved on the normal side (fig 176)

The patient may be able to walk after the accident. The position of the foot shows that there is no deformity and no shortening With a little encouragement the patient can lift the leg off the bed The radiograph comes as a surprise.

Fig 175 Abduction type of transcervical fracture of the neck of the femur

Fig 176 Abduction type of transcervical fracture of the neck of the femur
Note: the under surface of the neck is straight instead of curved.

Fig 177 *a* (*top*) Separation of the upper femoral epiphysis.
Mild gradual slip. *b* (*below*), lateral view

Treatment

The impaction is firm and should not be disturbed The patient remains in bed until she has regained control of the hip i.e. can lift the leg off the couch and rotate it in mid air Weight-bearing may be started as soon as the patient gets up provided that the abductors of the hip are strong enough to hold the leg in abduction when the patient stands on the leg The fracture line being horizontal, a shearing force does not act on it when the patient is weight bearing and there is therefore no risk of refracture The patient should be normal at the end of three months.

Alternatively the fracture may be pinned like the adduction fracture and the patient allowed to walk immediately

*SEPARATION OF THE UPPER EPIPHYSIS OF THE FEMUR

This is not common but is of great importance. It occurs between the ages of 12 and 15, earlier in girls than in boys.

The condition differs from other separated epiphyses in two respects it occurs spontaneously and the line of fracture is entirely through the epiphyseal line. It is due to the effect of body weight on newly formed bone of insufficient strength. The weakness is presumed to follow a disturbance of endochondral ossification resulting from a temporary dysfunction of the pituitary gland just before puberty Both hips are often affected, one after another: the epiphysis on the second side may even slip while the patient is in bed undergoing treatment for the first.

The shaft is externally rotated and displaced up on the epiphysis. The slipping may be gradual or sudden.

GRADUAL SLIPPING

This is apt to pass unnoticed. After playing a game a child complains of slight pain in the hip or *in the knee* and limps. The hip joint is normal on examination except for slight loss of internal rotation. The condition is often diagnosed as a sprain of the knee.

Although the physical signs are almost non-existent the radiograph is diagnostic. In the antero-posterior view there is widening and fluffiness of the epiphyseal line, and upward displacement of the shaft. The upward displacement is shown by the upper and lower borders of the neck (fig 177a). Normally the upper line of the neck if followed towards the head angulates sharply at the junction of the neck and the head. If the epiphysis has slipped the line continues on to the head without a step Also the epiphysis projects down below the lower line of the neck as a sharp hook. The lateral view taken with the hip flexed to a right angle and abducted as much as it will go is even more diagnostic (fig 177b).

Fig 178 Separation of the upper femoral epiphysis. Severe sudden slip.

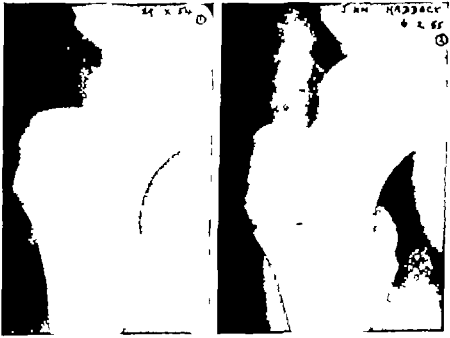

Fig 179. Fracture of the small trochanter Interval three months.

Treatment

Reduction is not possible because the separation is never at any time complete, and because there are no means of holding the head fragment while the shaft is being manipulated. All that can be done is to avoid further slipping by the prevention of weight bearing. A six inch patten is applied to the other boot so that the affected leg swings clear of the ground as the patient walks on crutches. A weight relieving caliper is sometimes used but the patient requires to be watched carefully because the splint often ceases to function. The ring slips up above the tuber ischii and then the splint no longer shortcircuits the body weight from the pelvis to the ground

If the other epiphyseal line is wider than normal this leg also must not bear weight, and the patient then stays in bed. Weight bearing is not allowed until the radiograph shows that the epiphyseal line has fused, which may take twelve months.

Slipped epiphysis occurs at a particular age period, namely just before puberty and as soon as puberty arrives the widened disc rapidly narrows and the head fuses with the shaft. It would seem advisable in theory therefore to hasten the advent of puberty by endocrine drugs. In practice they do not have much effect.

RAPID SLIPPING

There may or may not have been premonitory symptoms of gradual slipping, unrecognised or untreated. Suddenly during a game the child falls to the ground with severe pain in the leg. When seen in bed the foot is everted and the leg appears short. The patient is unable to raise the leg off the bed, and passive movements are not tolerated on account of pain. The antero-posterior radiograph is now unmistakable; the shaft is displaced up one inch and externally rotated (fig. 178).

Treatment

Reduction is best done gradually by traction because in spite of gross displacement the slipping may have been gradual in which case reduction is not possible and attempts at manipulative replacement endanger the blood supply of the epiphysis. Traction on the other hand will not do any harm even when reduction is not obtainable

Either skin or skeletal traction may be used. Since a weight of 20 lb. is often necessary skeletal traction is preferable on account of its greater comfort. Countertraction is applied by raising the foot-end of the bed. The leg lies free in bed. No attempt is made to control rotation, the external rotation displacement is automatically controlled by the longitudinal pull if the Steinmann's pin has been inserted correctly

Reduction by traction may take several days. The pull is then continued as a means of fixation. But, since fixation must be maintained until the epiphyseal

line has fused, it is often better to fix the fragment by means of a nail, as for a fracture of the neck of the femur This saves several months of recumbency

Unless the neck has been nailed weight should not be taken until the radiograph shows that the epiphysis has fused. Premature fusion is invariable.

* FRACTURE OF THE LESSER TROCHANTER

This is not common. It occurs in schoolboys, and is caused by vigorous contraction of the psoas muscle, as for example when a boy is hurdling

The boy falls to the ground with pain in the hip. When seen the position of the foot in bed is normal and there is not any shortening There is tenderness in Scarpa's triangle. Rotation of the hip is free, extension is painful. And active flexion of the thigh when sitting is not possible.

Since slipped femoral epiphysis is much more common at this age this should first be excluded when the radiograph is looked at. The separation may not be disclosed in an ordinary antero-posterior view and it may be necessary to repeat the X ray with the leg in external rotation in order to bring the small trochanter into view (fig 179).

Reduction is not necessary The boy remains in bed until he feels able to stand. The apophysis always joins on to the shaft with bone, and there is never any permanent loss of function (fig 179).

Fig. 180. *a* (*top*) Fracture of the shaft of the femur in baby. Massive callus. *b* (*below*), eighteen months later

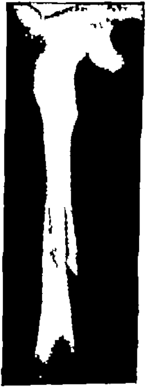

Fig 181 (*left*) Spiral fracture of the shaft of the femur in a child (*centre*) nine months later (*right*) normal femur for comparison.

Fig 182. Spiral fracture of the shaft of the femur in a child.

Fig. 183 Patient of fig 182 being treated by skin traction three weeks later

28

Fractures of the Shaft of the Femur

• FRACTURE OF THE SHAFT OF THE FEMUR IN THE NEW BORN

Transverse fracture of the middle of the shaft of the femur is a common birth injury No treatment is required. The baby's muscles immobilise the fracture. Union is rapid, and an X ray taken after two weeks shows massive callus (fig 180a). In an X-ray taken a year later it is difficult to identify the site of the fracture and the leg is not short (fig 180b)

• SPIRAL FRACTURE OF THE SHAFT OF THE FEMUR

This is common in young children as a result of a fall. The fracture line is a long spiral extending over a quarter of the length of the shaft (fig 182) There is overlap and lateral shift, and usually angulation.

The child refuses to stand or to move the leg in bed. There is apparent shortening and the unnatural shape of the thigh makes it obvious that the femur has been broken.

Treatment

This is delightfully simple. Adhesive-strapping tractions (fig 20) reaching up to the groin are bandaged on to the skin, and tied to the end of the cot or bed, and the foot-en of the bed is stood on a kitchen chair No other splintage is necessary T tion reduces the overlap, and rotation corrects itself when t e pulled on Lateral shift remains but luckily it does not matter

In this fracture splintage is used to hold the ends in good alignment and not to keep the bone ends still, the muscles safeguard the fracture site from harmful stresses. The child is encouraged to move about in his cot, and within two or three weeks it is not unusual to find that he is lying on his face with the fractured leg still tied to the end of the cot, or that he is even attempting to stand up (fig 183).

Fig. 184. Fracture of the upper third of the femur Reduced by skin traction.

At the end of six weeks the skin traction is removed, and the child is allowed to kick about in bed. Within a few days he will be found standing in his cot. He may then be got up without crutches or sticks. The fracture is not consolidated for twelve weeks, but being a spiral fracture it is not affected by angulation, nor is it subjected to rotational stresses because the hip is free. Weight bearing may therefore be allowed before the fracture has consolidated.

Recovery is perfect. After repair there may still appear to be an overlap in the radiograph, but clinically this is not obvious. Within a year all signs of fracture have disappeared (fig 181). The child can easily be treated at home.

** TRANSVERSE FRACTURE OF THE SHAFT OF THE FEMUR

This is a common fracture in adults as a result of a motorcycle accident. The *fracture is complete,* and is sometimes open. The line of fracture is transverse but there is often a short spike on one fragment. The bones are overlapped, there is backward bowing and the lower fragment is externally rotated on the upper In the upper third the upper fragment is abducted (figs. 184, 186a).

The position of the foot shows the eversion and the shortening. The patient cannot lift or move the leg. It may be difficult to locate the site of the fracture, and as movements of the leg are painful it is better, as soon as a fracture is suspected, to suspend examination until the radiograph has been seen.

First-aid treatment

A fracture of the shaft of the femur causes great shock, which may be fatal. The shock is brought about mostly by the pain caused by the movement of the uncontrolled bone-ends, and it is better to splint the fracture before the patient is moved. A Thomas's bed knee splint is invaluable for this purpose (fig. 184). The ring is slipped over the man's shoe, and the splint is threaded up the

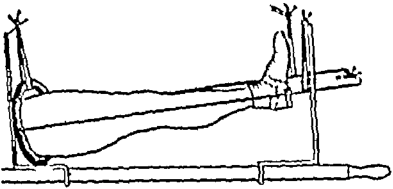

Fig. 184. First-aid treatment by a Thomas's splint of any fracture of the leg above the ankle

thigh as far as it will go. An assistant all the time is gripping the ankle and pulling in the line of the leg. If a metal skewer is available this is passed transversely through the shoe just below the man's heel after two holes have been cut in the leather. While the leg is still being pulled on, two strings from the two ends of the skewer are tied tightly to the end of the splint. If a skewer is not to hand a figure-of-eight bandage is wound round the ankle and the two ends of the bandage left free to be pulled down and tied to the end of the Thomas's splint. Morphia is given and the patient is kept warm while he is waiting for the ambulance to arrive.

Reduction

A transverse fracture can sometimes be made to hitch by the angulation meth The fragments are sharply angulated, the ends are placed in contact and the is straightened. Reduction is then maintained by traction. If the position is stable reduction is obtained gradually by traction (fig. 186a).

Splintage

Extra splintage is not required. The muscles protect the site of the fract from harmful stresses and also cause the two bone ends to press against

Fig. 184. Fracture of the upper third of the femur Reduced by skin traction.

At the end of six weeks the skin traction is removed, and the child is allowed to kick about in bed. Within a few days he will be found standing in his cot. He may then be got up without crutches or sticks. The fracture is not consolidated for twelve weeks, but being a spiral fracture it is not affected by angulation, nor is it subjected to rotational stresses because the hip is free. Weight bearing may therefore be allowed before the fracture has consolidated.

Recovery is perfect After repair there may still appear to be an overlap in the radiograph but clinically this is not obvious. Within a year all signs of fracture have disappeared (fig 181) The child can easily be treated at home.

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The position of the foot shows the eversion and the shortening The patient cannot lift or move the leg It may be difficult to locate the site of the fracture, and as movements of the leg are painful it is better as soon as a fracture is suspected, to suspend examination until the radiograph has been seen

First-aid treatment

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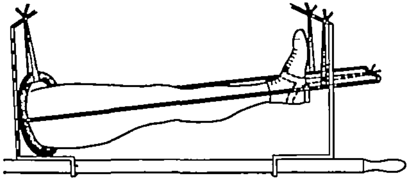

Fig 185 First-aid treatment by a Thomas s splint of any fracture of the leg above the ankle.

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Reduction

A transverse fracture can sometimes be made to hitch by the angulation method. The fragments are sharply angulated, the ends are placed in contact and the leg is straightened. Reduction is then maintained by traction. If the position is not stable reduction is obtained gradually by traction (fig 186a).

Splintage

Pure splintage is not required. The muscles protect the site of the fracture from harmful stresses and also cause the two bone ends to press against one

Fig 184. Fracture of the upper third of the femur Reduced by skin traction.

At the end of six weeks the skin traction is removed, and the child is allowed to kick about in bed Within a few days he will be found standing in his cot. He may then be got up without crutches or sticks. The fracture is not consolidated for twelve weeks, but being a spiral fracture it is not affected by angulation, nor is it subjected to rotational stresses because the hip is free. Weight bearing may therefore be allowed before the fracture has consolidated.

Recovery is perfect. After repair there may still appear to be an overlap in the radiograph, but clinically this is not obvious. Within a year all signs of fracture have disappeared (fig 181). The child can easily be treated at home.

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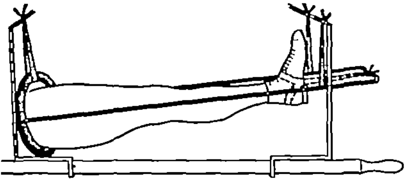

Fig 185 First-aid treatment by a Thomas s splint of any fracture of the leg above the ankle.

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Splintage

PURE splintage is not required. The muscles protect the site of the fracture from harmful stresses and also cause the two bone ends to press against one

Fig 184. Fracture of the upper third of the femur Reduced by skin traction.

At the end of six weeks the skin traction is removed, and the child is allowed to kick about in bed. Within a few days he will be found standing in his cot. He may then be got up without crutches or sticks. The fracture is not consolidated for twelve weeks, but being a spiral fracture it is not affected by angulation, nor is it subjected to rotational stresses because the hip is free. Weight bearing may therefore be allowed before the fracture has consolidated.

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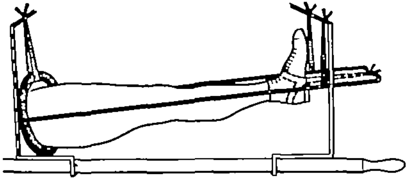

Fig 185 First-aid treatment by a Thomas's splint of any fracture of the leg above the ankle.

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Splintage

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Fig 186. *a* (*top*) Fracture of the upper third of the femur treated by skeletal traction. The patient has Paget's disease. *b* (*below*), four weeks after the injury patient lifting her leg and bending her knee.

another SIMPLE splintage is needed to maintain alignment. Skeletal traction answers all the requirements. A Steinmann's pin is passed transversely through the anterior half of the tibia one inch below the tubercle. The tibia is chosen rather than the femur because transfixing the femur interferes with the action of the thigh muscles. Cords from the ends of the Steinmann's pin are passed over pulleys fixed to the end of the bed. If the bone ends are flush a 20 lb weight is sufficient: if not, 30 lbs. or more may be necessary to distract the bones sufficiently to allow them to come end to-end. Countertraction is afforded by raising the foot end of the bed the amount of raise is regulated so that the patient slips neither up nor down the bed (fig 186). A good working rule is to raise the end of the bed one inch for every lb weight

The leg lies free on the bed It is customary to cradle the leg in a Thomas's splint, but this is unnecessary and the patient is more comfortable without this splint. A pillow is placed lengthwise under the leg: this lifts the heel off the bed and allows the knee to flex a little.

If the skin holes where the pin emerges get sore the pin must be removed and a new pin inserted lower down. If the pull on the two cords is not equal and not exactly parallel to the leg the pin tends to shift sideways in the bone and the skin holes get sore. Careful attention to the direction of the pull of the cords and sealing the skin holes with collodion allows skeletal traction to remain on for the whole of the time.

There is no fear of a dropped foot and the foot need not be supported. A cradle should be used to keep the bed clothes from pressing on the toes.

The tendency for the femur to bow backwards has to be remembered. Traction gets rid of the actual backward bow but this is not enough, for the normal femur is bowed forwards and this forward bow should be restored A sling six inches wide is passed under the thigh at the upper end of the lower fragment (it must not be too high otherwise it acts on the upper fragment) and cords from its four corners are joined to a single cord, which passes over a pulley fixed directly overhead. A weight of 5 to 10 lbs. is sufficient to restore the normal anterior bow Rotation corrects itself The longitudinal muscles when pulled upon naturally take the shortest course between their origin and insertion, and this places the ends of the bones in correct axial alignment.

The essentials of splintage are therefore longitudinal traction, and a pillow lengthways under the leg.

A rope for the patient to raise himself is suspended above the bed. Within a few days the patient has learnt, if he has been taught, the knack of lifting his trunk off the bed, keeping his hip extended at the same time (fig 187c) The patient can also pull himself up the bed by bending the other knee and digging the heel into the bed, at the same time lifting his trunk free of the bed by hauling on the overhead rope It is never necessary for the weights to be lifted and the nurses are warned against interfering with them.

The ordinary hospital bed is used with two alterations. Two half mattresses

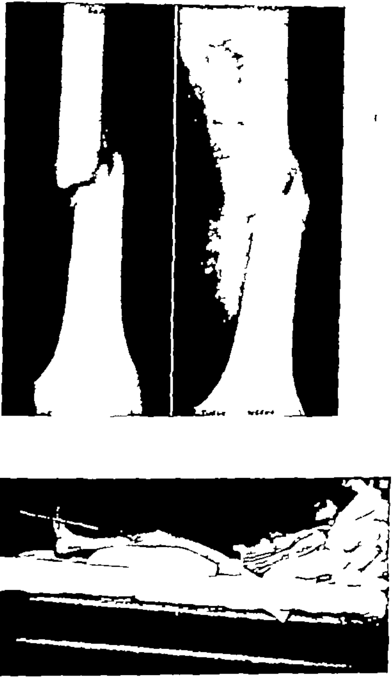
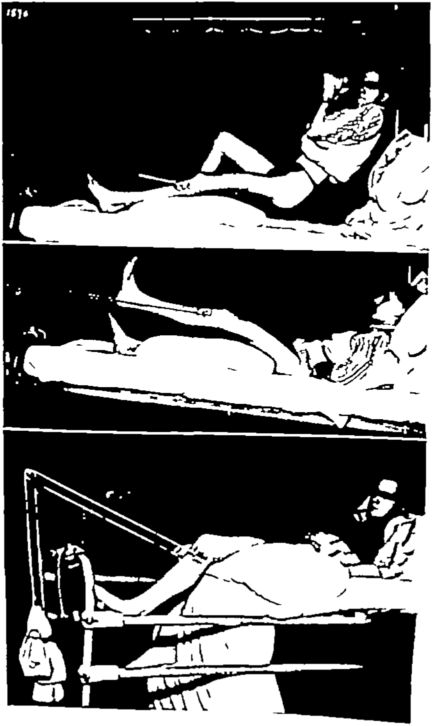


Fig 18 *a* (*top*) Oblique fracture of the shaft of the femur six weeks and twelve weeks after the injury *b* (*below*) lying in bed at rest; *c* (*opposite*), patient lifting his buttocks off the bed, lifting his leg, and bending his knee.



replace the usual *single mattress, and fracture boards replace the usual spring.* When the lower mattress and the underlying fracture boards are removed the patient is able to bend his knee to a right angle.

Treatment of the soft parts

A physiotherapist is indispensable. And if she knows little about massage, so much the better. Her task is three-fold: to make the patient move fully all his free joints; to make him lift his leg; and to make him bend his knee.

It is most important to get the patient to contract his thigh muscles. The physiotherapist usually concentrates on the quadriceps and the patient is told to contract his quadriceps. This is double dutch to him. He should be told something he understands: he should be exhorted and bullied *to lift his leg off the bed.* A good physiotherapist will persuade a patient with a fracture of the shaft of the femur to lift his leg off the bed within a fortnight of the accident. At first when the patient lifts the leg the femur bows forwards in an ugly manner: this is all to the good because it counteracts the natural tendency for the broken femur to bow backward. At the end of about two weeks or as soon as the patient can lift his leg with the knee extended, the lower fracture boards are removed and the lower half of the mattress is let down from time to time. The patient can then bend his knee (figs. 187c, 188).

A portable X-ray is of advantage. Its value lies not so much in demonstrating alignment, for this can be assessed clinically, but in showing whether the bone is being overpulled. If the bone ends are separated by the traction repair will be by fibrous tissue and not by bone. The least possible amount of traction should be used, and it is usual to drop from 20 lbs. to 10 lbs. at the end of six weeks.

The whole apparatus is simple. Nevertheless the leg should be inspected daily and the movements and exercises superintended. The patient is soon comfortable and the amount and vigour of the muscle contractions in a few weeks is astonishing.

Any complaint should be investigated. The three common causes of discomfort are soreness at the back of the heel, hyperextension of the knee, and sore pin holes.

Protection

Union cannot be expected under twelve weeks. This is a long time, and most cases of non-union of the femur arise because sufficient time is not allowed for stage II of treatment.

At the end of twelve weeks the sling under the thigh is removed and the weights are lifted and placed on the bed. For a week or two the patient lies free in bed. If the radiograph shows good ensheathing callus and the patient is comfortable, the Steinmann's pin is withdrawn and the patient is got up. But weight bearing is not permitted for another twelve weeks, making six

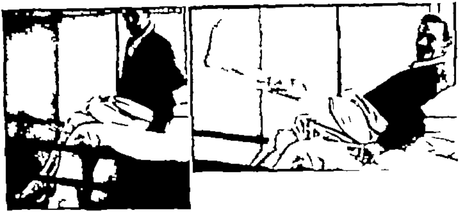


Fig. 188. Spiral fracture of the shaft of the femur Patient exercising his knee seven weeks after the injury

months from the time of the accident. Consolidation cannot be expected before this.

Weight-bearing can be prevented by a weight relieving caliper This is a Thomas s bed knee splint, the ends of which have been cut off turned in at right angles and fitted into sockets in the heel of the shoe. As a splint it is unreliable. The ring has to fit accurately otherwise it slips up above the tuber ischii and ceases to shortcircuit the weight. Even when the splint is efficient at the time the patient leaves the hospital the ring may have slipped up before he is seen again. Moreover by keeping the patient s knee straight it prevents him from walking properly It is better to rely on crutches and not to put any weight on the leg The patient is taught to go through the actions of normal walking without taking any weight through the leg

In the fifth month from the accident the patient is encouraged to take weight on the leg It is several weeks before he can balance on the leg

Treatment by internal fixation

The treatment outlined above is safe but the patient has to spend a long time in bed, and surgeons have tried to shorten the period of recumbency by plating the femur A plate however is not strong enough to allow the patient to take weight on the leg and when the patient does start weight bearing the plate often breaks (fig 190). A long intramedullary nail introduced by Küntscher at the beginning of the 1939/45 war has revolutionized the treatment of a transverse fracture of the shaft of the femur The nail, which is almost as long as the shaft of the femur is driven through the great trochanter down inside the shaft (fig 189). The site of the fracture usually needs exposing so that the two ends of the shaft can be brought into apposition before the nail is driven home. After the operation the leg lies free in bed. As soon as the patient has gained muscular control over the leg (as soon as he can lift the leg off the bed with the knee

straight) he is allowed up weight bearing The *advantages of early ambulation* and early unrestricted knee movement make this technique one of the most valuable of the recent advances in the treatment of fractures

Complications

Malunion. Overlap is not serious and can be compensated if necessary by a raised heel. Severe backward bowing makes sitting uncomfortable and by throwing the line of the weight in front of the knee puts a hyperextension strain on that joint.

Delayed union. This is common because splintage is not continued long enough and weight bearing is allowed too soon. The feeble union refractures insidiously and the femur bows outward (fig 190). Then at every step the patient takes, the bone hinges at the site of fracture, and the delayed union passes on to non-union. *It should be emphasised that although taking weight* on a straight bone is the best incentive to bony union taking weight on a bent bone is the best way of getting fibrous union.

Both delayed union and non union are treated in the same way namely by the insertion of a Küntscher nail and weight bearing on the straight femur

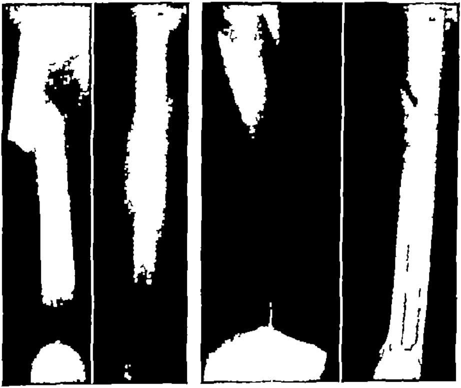


Fig 189. *a* (*left*) Transverse fracture of the shaft of the femur treated by Küntscher nail, *b* (*right*), lateral view

Stiff knee Stiffness of the knee is the bugbear after a fracture of the shaft of the femur It can be avoided by purposive activity of the leg while the patient is in bed. The knee should bend to a right angle by the time the patient gets up If the thigh muscles are allowed to remain inactive while the patient is in bed flexion will be long in returning and in spite of vigorous stretching under anaesthesia the ultimate range of movement may not exceed 45 degrees.

Transportation of a patient with a fractured femur

Apart from the three complications of an open wound, severe loss of blood, and shock, there is in wartime the additional complication that the soldier will probably have to pass through one or more centres before he becomes stationary For transporting a man with a fractured femur nothing better has been found than the 'Tobruk splint The foundation of the Tobruk splint is a Thomas s bed-knee splint. The Thomas s splint is used as it was originally designed to be used with fixed traction and fixed countertraction In addition, a circular plaster is wound round the leg and the Thomas s splint, and moulded to both. The plaster holds the upper end of the Thomas s forwards on the

Fig 189c (*left*). Patient of fig 189a and b twelve months after the injury
Fig 190 (*right*). Non-union of a fracture of the shaft of the femur which had been treated by a plaster spica, plating and grafting

thigh so that the ring cannot slip up beyond the tuber ischii; it also cradles the leg so that it is immobile within the Thomas's splint.

On the man's arrival at a stationary hospital the Tobruk splintage may be continued or it may be replaced by one of the two standard methods described above.

LONGITUDINAL FRACTURE OF THE SHAFT OF THE FEMUR

This is not common. It occurs in adults who fall from a height. Multiple longitudinal fracture lines run up and down the shaft. Some of these are simple cracks without displacement, some are complete and form long spikes which separate from the main shaft. There is often very little displacement. Although the fracture looks alarming in the radiograph it is often easy to treat.

When the fracture is complete treatment does not differ from the traction method used for a transverse fracture, with the exception that one of the spikes may have penetrated the quadriceps muscle or the capsule of the knee joint. Traction restores the bone to its normal length but leaves behind a detached spike still embedded in muscle or joint, and open operation may be necessary to extricate it.

Longitudinal fractures are not suitable for intramedullary nailing since the stability of the bone has been lost over a considerable area. For the same reason repair takes longer than with the simple transverse fracture.

On the other hand when the fracture is incomplete repair is rapid, and delayed union and non-union do not occur. It is a friendly fracture to treat.

Fig 191 a (*left*) Supracondylar fracture of the shaft of the femur b (*right*) six months later

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Injuries around the Knee

** FRACTURES OF THE FEMORAL AND TIBIAL CONDYLES

There are many anatomical varieties and they are caused in different ways but they are grouped together because they can only be distinguished by radiographs and they can all be satisfactorily treated by the same method, namely a combination of skeletal traction and active movement of the knee.

The knee is swollen and may be deformed. It is obvious that there has been a severe injury but usually the swelling makes exact diagnosis difficult. For the comfort of the patient no further examination should be made until after a radiograph has been seen.

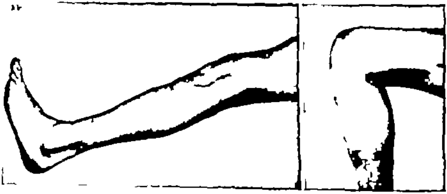

Fig 193b Range of movement twelve months later

Fig. 192. T-shaped fracture of the femur into the knee joint.

Fig. 193a. Fracture of a femoral condyle

29

Injuries around the Knee

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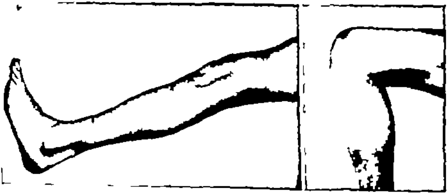

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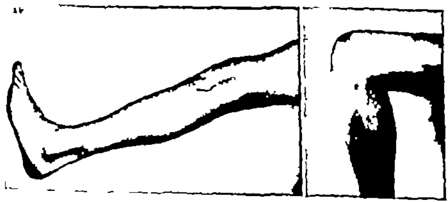


Fig 193b Range of movement twelve months later

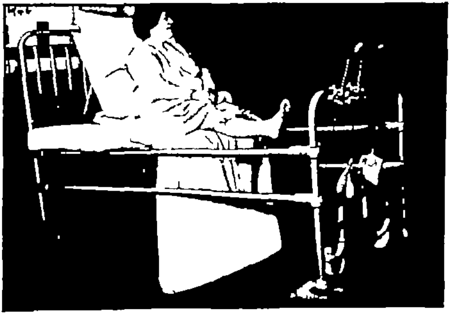


Fig. 194. *a* (*top*) Fracture of the femoral condyle with subluxation of the knee. *b* (*below*), patient exercising the knee. *c* (*see opposite page*).

SUPRACONDYLAR FRACTURE OF THE FEMUR

This is caused by a direct blow just above the knee. The fracture line is transverse, two or three inches above the joint. Usually displacement is small (fig 191). Occasionally however the lower fragment rotates back and the shaft over lies it in front Although not common this is an important fracture, first because when there is overlap the popliteal vessels are pressed upon by the lower fragment and the leg may become gangrenous, and second on account of the difficulty of reduction. Open reduction is sometimes necessary Once reduced the fracture is stable and can be treated in the routine way from then on (see page 287).

T SHAPED FRACTURE OF THE FEMUR INTO THE KNEE JOINT

This is an uncommon fracture met with in adults who have fallen on to a bent knee. There is a transverse fracture a few inches up from the joint, and a vertical split runs up between the condyles to join it (fig 192). At the transverse fracture the fragments are end-on, although there may be angulation and a shift in one or more planes. The condyles may be separated by a gap and one condyle is often displaced upon the other For treatment, see page 287

FRACTURE OF THE FEMORAL CONDYLE

When a leg is struck on the outer side and the knee forced into valgus, the lateral condyle of the tibia usually bears the brunt of the force and breaks,

FIG. 194c Range of flexion obtained. This was all she had before the fracture; the loss of movement had followed an arthrodesis of the hip on the same side.

occasionally the lateral condyle of the femur breaks instead. The femoral condyle may be displaced laterally and outwards, taking with it the tibia, so that the joint is subluxated (fig 194) Traction on the leg reduces subluxation and the femoral condyle falls back into position. For further treatment, see page 287

FRACTURE SEPARATION OF THE LOWER EPIPHYSIS OF THE FEMUR

There is an ancient and a modern version of this injury Formerly a boy riding on the back of a cab caught his foot in the spokes of a wheel. The knee hyper extended, the epiphysis separated completely from the shaft and then shifted backwards and pressed on the popliteal vessels. If reduction was delayed there was a risk of gangrene. Reduction was obtained by pulling in the direction of the shaft of the femur while the knee was bent to a right angle. This injury is seldom seen now

In the modern version an adolescent injures his knee at football. The fracture line passes partly through the growth disc and partly through the metaphysis. Except for a medial or a lateral hinge displacement is slight.

Reduction

Displacement is easily reduced by manipulation.

Splintage

Although this injury can be treated in the routine way by skeletal traction, it is equally well treated in a plaster-of paris cast. The plaster holds the leg in correct alignment. It reaches from below the groin to just above the ankle. The cast is kept on for six weeks. Thereafter the patient gradually regains full movement by ordinary use of the leg Subsequent interference with growth is rare.

INFRACONDYLAR FRACTURE OF THE TIBIA

This is not a common fracture. It is caused by a blow on the upper part of the leg. The tibia fractures transversely two inches below the knee joint and the fibula breaks at the same level. There may be slight lateral shift but there is not any overlap or rotation, the principal displacement is angulation which may be in any direction. Skeletal traction corrects any angulation but should it fail to do so the leg is manipulated and put into plaster reaching from the middle of the thigh to behind the heads of the metatarsals. It is important to correct angulation. If the patient is left with a backward bow the knee hyper extends afterwards and strain is put on the posterior ligament of the knee worse still if he is left with an outward bow for then genu varum occurs and this is invariably followed by severe osteoarthritis of the knee joint.

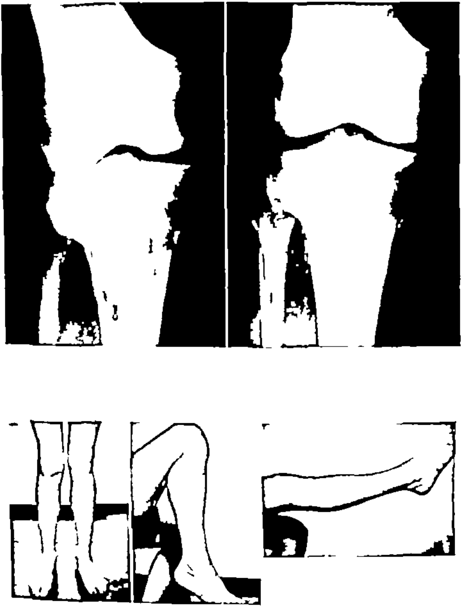


Fig 195 *a* (*top*) T-shaped fracture of the tibia into the knee joint. Six weeks interval. *b* (*below*) four months after the injury

Fig. 196 *a* (*left*), Fracture of the lateral condyle of the tibia. Little displacement.
b (*right*) range of movement at the end of ten days.

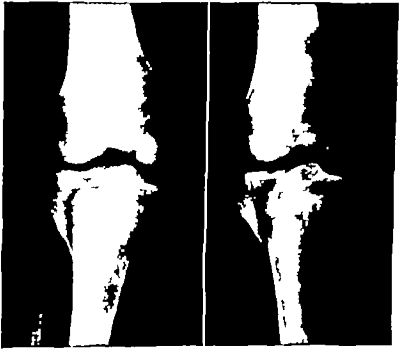


Fig. 197 *a* Fracture of the lateral condyle of the tibia.
Genu valgum corrected by traction.

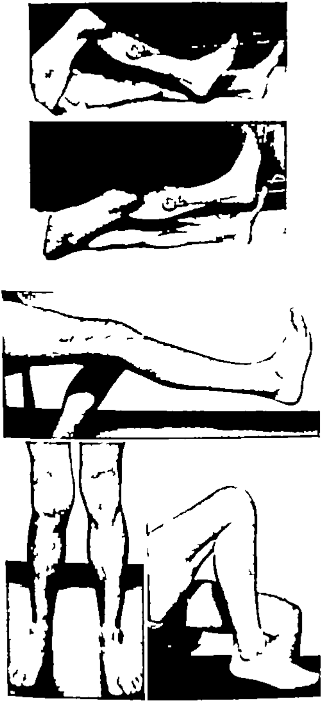


Fig. 197 *b* (*top*), Patient lifting his leg and bending his knee at the end of ten days; *c* (*below*) three months after the injury as he was about to return to work as a London bus driver

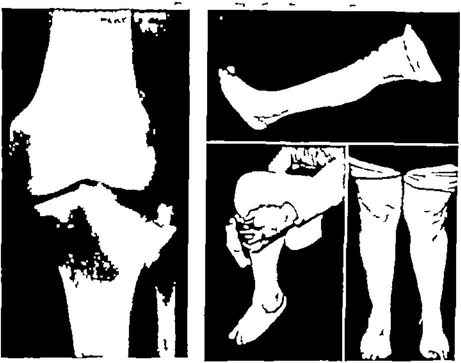


Fig. 198 *a* (*left*), Fracture of the lateral condyle of the tibia. Comminuted. *b* (*right*) deformity and range of movement.

T SHAPED FRACTURE OF THE SHAFT OF THE TIBIA INTO THE KNEE JOINT

This fracture is met with in adults when a longitudinal force travels up the leg The usual history is a fall from a height. The shaft of the tibia is driven up between the condyles like a wedge and both tuberosities are split off (fig 195). The fragments may splay out and the shaft ride up between them. Skeletal traction brings about an accurate reduction. For further treatment, see page 287

FRACTURE OF THE LATERAL CONDYLE OF THE TIBIA

This is a common fracture in women and men past middle age. In the belief that the patient was usually knocked down by a car this fracture has been called the bumper fracture. Actually it is just as common for the patient to say that she slipped and fell while in her own home.

Three anatomical varieties are distinguished. (*a*) The fibula remains intact and the condyle of the tibia splits vertically and the lateral portion is shifted or hinged outwards (fig 196*a*) (*b*) The neck of the fibula also breaks, and the split-off fragment of lateral condyle is displaced downwards with its articular

Fig. 199. Skeletal traction, patient bending the knee and lifting the leg with the knee straight.

surface unharmed (fig 197a) (*c*) The neck of the fibula remains intact and the articular surface of the lateral condyle is pulped (fig 198a).

Reduction of any displacement is difficult except at an open operation and it is impossible if the articular platform has been comminuted. Luckily experience has shown that in most cases the displacement may be disregarded. When treated by the routine method the patient regains full movement of the knee (fig 198b) The knee usually exhibits a slight amount of genu valgum but this does not cause any disability and the joint, which at the time of the accident could be hinged outwards, is quite stable. For treatment, see below

Treatment of all fractures of the femoral and tibial condyles

They can all be treated in the same way by a combination of skeletal traction and active movements of the knee. The traction reduces any displacement and maintains the reduction, and makes the patient comfortable Early active movements push back into place any piece of bone that projects above the articular platform and ensures that the opposing articular surfaces shall be congruous

A Steinmann's pin is driven transversely through the anterior half of the tibia, either in the usual spot—one inch below the tubercle of the tibia (fig 199)—or in the case of a tibial fracture, lower in the tibia (fig 197) or through the body of the os calcis. A pull of 10 lbs. is sufficient, and the foot-end of the

Fig. 200 Dislocation of the knee.

Fig 201 Dislocation of the patella.

bed is raised 10 inches to supply countertraction. The leg is cradled on a pillow placed lengthwise. The pillow holds the knee in slight flexion, which is the position of comfort, and raises the leg so that the heel does not press into the bed.

The physiotherapist gets to work on the day after the accident. Her job is to see that the patient moves his ankle, tarsal and toe joints, and to get him to lift his leg off the bed with the knee straight, and to get him to bend his knee. An ordinary bed is used except that the mattress is in two halves and the bed spring is replaced by fracture boards. When the fracture boards are removed from the lower half of the bed and the mattress is let down the patient is able to bend his knee to a right angle (fig 194b).

When there has been no displacement and when there is no lateral wobble traction is not needed. In other cases traction is usually retained for six weeks. As soon as the traction has been discarded the patient is got up and taught to walk, at first on crutches. Most of the patients gain full movement at the knee and are walking normally within three months of the accident.

* AVULSION OF THE TIBIAL TUBERCLE

This happens to a young child. In the adult the ligamentum patellae ruptures instead. The ligamentum patellae is attached to the shaft of the tibia by means of an apophysis. This may be a separate piece of bone or a tongue-like extension downwards of the epiphysis of the tibia. When the quadriceps is strongly put into action while the knee is being forcibly bent, either the apophysis is avulsed or the whole of the epiphysis is tilted upwards. This type of accident happens when a person tries to save himself from overbalancing

This injury is an exception to the general rule since it is better treated in plaster than by skeletal traction. A complete separation comparable to that at the lower end of the femur does not occur

Often there is no displacement of the apophysis, and the history of trauma is vague. The condition is then known as Schlatter s disease or osteochondritis

** DISLOCATION OF THE KNEE JOINT

Despite the apparent insecurity of the joint dislocation of the knee is not common. It is caused by great violence, and the tibia may be displaced in any direction (fig 200). Sometimes the popliteal vessels are severely damaged and immediate amputation is necessary Temporary paresis of the lateral popliteal nerve is common.

Treatment

Reduction as a rule presents no problems, although inclusion of a portion of the medial lateral ligament sometimes necessitates open reduction. This is likely to have happened when there appears on palpation to be nothing between the skin and the underlying bones. Advantage is taken of the operation

to sew back the torn ligament. After reduction the knee is immobilised at about 170 degrees in a plaster cast which extends from the top of the thigh to behind the heads of the metatarsals. The patient is allowed to bear weight as soon as he can lift his leg off the bed. He is taught to walk naturally and is not allowed to pivot on his heel. It is essential for the flexors and extensors of the knee to contract and relax in succession at each step in walking: this prevents loss of extensibility of muscles, which is the main cause of joint stiffness after immobilisation.

After six weeks the circular plaster is removed and a plaster gutter holding the knee straight and in full extension is substituted. This is worn while the patient is weight-bearing until the muscles have regained sufficient strength to stabilise the knee. Muscle power is restored by faradism and exercises, for which the splint is temporarily removed.

A dislocation of the knee can be equally well treated by the routine method for fractures of the condyles, namely skeletal traction combined with active movements of the knee. The patient's stay in hospital is longer but he is back at work more quickly.

Prognosis is surprisingly good. The knee is insecure but no more than after a simple tear of a crucial ligament unaccompanied by a dislocation.

• DISLOCATION OF THE PATELLA

The patella occasionally dislocates outwards as the result of injury (fig. 201). It travels beyond the ridge of the lateral condyle and then rotates so that its articular surface lies against the lateral aspect of the condyle. The dislocation is caused by sudden unco-ordinated muscle action. The fibres of the vastus internus attached to the medial border of the patella are stretched or torn.

The knee is held flexed and is a peculiar shape. Diagnosis is simple to one familiar with the condition. The patella is palpable in its displaced position. The patient will not move his knee and is in great pain.

Treatment

As soon as the muscles relax under anaesthesia it is easy to glide the patella back into position, where it is stable. Ordinary use is allowed afterwards in spite of a large effusion into the joint. Faradism to the quadriceps and exercises are started at once.

RECURRENT DISLOCATION OF THE PATELLA

Recurrence is not common after a first dislocation in adult life. Often however the patient gives a history of recurrent trouble with the knee dating back to childhood. As a rule the patella subluxates rather than dislocates: it passes laterally, perches for a second on the ridge of the condyle, and then slides back into position.

Transplanting the tubercle, into which the ligamentum patellae is attached, to the medial side of the shaft of the tibia prevents the patella from subluxa-

Fig. 202 (*left*) Fracture of the tibial spine in a child, (*centre*) after closed reduction, (*right*) six weeks later

ting When repeated subluxations have damaged the articular cartilage excision of the patella is probably the better treatment. The subject is dealt with more fully in books on orthopaedic surgery

• FRACTURE OF THE SPINE OF THE TIBIA

This is a common knee injury in a child. A force acts on the bent knee and drives the femur back on the tibia, as happens when a child falls on its knee. It is a rare injury in the adult. At the time of the accident tension is put on the anterior crucial ligament and the bed of bone from which the ligament rises is uprooted and a wedge-shaped piece of bone is hinged upwards.

The knee immediately balloons with blood, and movement at the joint may be impossible on account of pain. Tenderness is present but it is not concentrated over the attachment of the lateral ligaments or the semilunar cartilages. The diagnosis is made on the lateral radiograph (fig 202) which shows an abnormal triangular piece of bone wedged in between the tibia and the femur in the front half of the joint. The diagnosis is sometimes missed, and after the patient has recovered from what was thought to be a sprain the knee is found to be 10 degrees short of full extension.

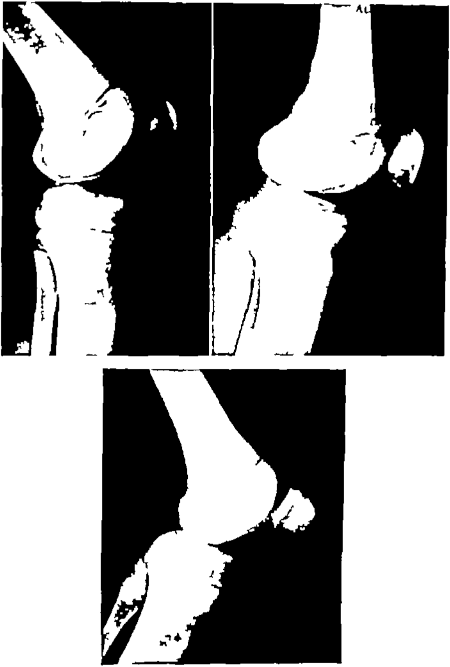


Fig. 203 *a* (*top*) Fracture of the tibial spine in a child. Open reduction. *b* (*below*) five years later

Treatment

Under anaesthesia the knee is extended fully Although the fragment may not be completely replaced it is reduced far enough to permit full extension (fig 202). Afterwards, a circular plaster is put on, holding the knee at 180 degrees. It extends from the upper part of the thigh to just above the heads of the metatarsals. The patient is allowed up at once and is taught to walk as naturally as possible. The plaster remains on for six weeks. Knee movements gradually return with ordinary use of the leg

If the patient is not seen within a week of the accident the knee joint must be opened and a cavity dug out of the upper end of the tibia big enough to receive the fragment (fig 203). The fragment is retained in position in its new bed by strong catgut sutures which are passed through the tibial platform and tied over the front of the tibia. A plaster is then applied and the routine treatment for a recent fracture carried out.

Fig 204. *a* (*above*), Direct fracture of the patella. *b* (*below*), range of movement at the end of fifteen days

Fig. 205 Indirect fracture of the patella. No separation.

FRACTURES OF THE PATELLA

Adults frequently break their knee caps The injury is very rare in children.

In the patella the problem of getting union is non-existent because a fibrous union is as good as a bony union. There are nevertheless two problems. Unless reduction is exact there will be irregularity of the articular surface of the patella. When there are several fragments it is impossible to get exact reduction, and under these circumstances it is better to mould the articular surfaces by early movement of the knee. The second problem concerns the method of production of the fracture A patella may be broken by direct or indirect violence In a direct fracture the patient falls and his knee cap hits the ground. In the indirect fracture the patient to save himself from falling contracts his quadriceps while his knee is bending under the influence of body weight. In this case the patella breaks and in addition the quadriceps expansion tears across. Thus there are two essentials in the treatment of a fractured patella, to suture the quadriceps expansion if it has been torn and to restore congruity to the patello-femoral surfaces by early active movement of the knee.

DIRECT FRACTURE OF THE PATELLA

The patient is a young man The fracture is caused by a blow or a fall on the bent knee. The patella is squashed and in a lateral radiograph is seen to have lost its normal shape (fig 204a). The quadriceps expansion is intact.

Although the quadriceps is intact the patient may be inhibited from raising

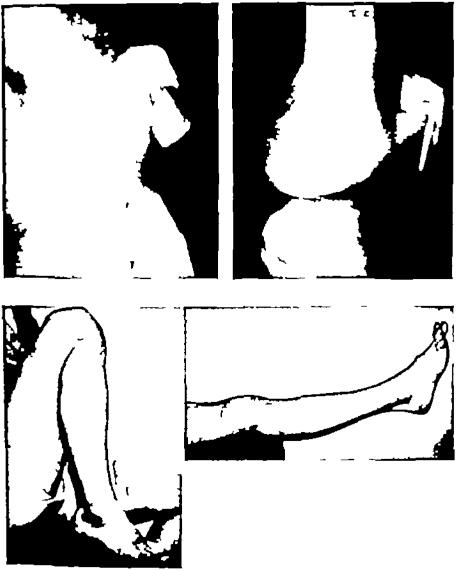


Fig 206 *a* (*top left*) Indirect fracture of the patella. Wide separation. *b* (*top right*), three weeks after the operation, (*below*) six months after the operation.

his leg by pain However when he makes an effort to raise his leg off the couch it is usually possible to feel tautening of the ligamentum patellae

Occasionally the patella is split into two without being squashed (fig 205). The two fragments do not then separate and the patient is able to walk, and the diagnosis of a fractured patella may not cross the mind of the examining doctor From the point of view of treatment this does not matter but in the law courts a doctor is held to blame for missing the diagnosis. Moral. never try to save expense; insist on an X ray examination after every injury however trivial.

Treatment

The patient is kept in bed until he has regained control of the knee In about a week he can hold his knee extended against resistance; he is then allowed up (fig 204b) He is urged to move the knee from the start because movement is relied on to iron out the irregularities of the articular cartilage on the back of the patella.

Occasionally the patella is grossly squashed. When this happens some surgeons excise the mushed bone at once. Others treat the knee conservatively to start with, and only excise later if the misshapen patella proves to be a disability

** INDIRECT FRACTURE OF THE PATELLA

The patient is a man past middle age who missteps, stumbles, hears something snap in his knee, and falls to the ground. He is unable to walk. The patella is split horizontally into two halves, which separate (fig. 206a) The upper fragment is pulled up by the quadriceps and is often tilted. The gap in the bone can be felt The quadriceps expansion on both sides of the patella is torn across and the patient is unable to tauten his ligamentum patellae. The lateral radiograph shows the patella in two halves, which if approximated would reconstitute a patella of normal shape.

Treatment

The important task is to repair the torn quadriceps. Through a transverse incision the whole extent of the tear is exposed, and the torn expansions are joined by strong catgut sutures. To prevent the sutures tearing out the two fragments of the patella are fastened together This used to be done by a piece of wire passed through or round the fragments. A more secure hold is obtained by a screw passed vertically through the fragments (fig 206b). Although firm fixation is obtained by means of the screw the quadriceps expansion must also be repaired, for that is the important part of the operation After the operation the patient can safely start bending his knee as soon as he can hold it extended. As soon as he has regained good control of the knee he is got up and taught to walk without any splint. Early active movement ensures that the patient regains a full range: the knee becomes as good as it was before the accident (fig 206c)

30

Injuries of the Leg

• FRACTURE OF THE SHAFT OF THE TIBIA IN A CHILD

A young child after a fall refuses to take weight on the leg. The physical signs are few and the diagnosis is deduced from the history. The radiograph shows a long spiral fracture, usually in the lower half of the bone (fig. 207a). Displacement if any is small and often the fracture is not complete.

Treatment

This depends on whether the fracture is complete. For the incomplete fracture reduction is of course not needed, nor is splintage. If left alone the child starts to walk again in a week or so.

In the complete fracture also reduction is not required because subsequent growth smooths out all irregularities (fig. 207b). An anaesthetic however is needed for putting on a plaster cast. The plaster reaches from the upper part of the thigh to behind the heads of the metatarsals. Care is taken to get the foot plantargrade, i.e. at right angles to the leg and parallel to the ground. To make the patient comfortable the splint must prevent rotation at the site of the fracture. Since it is easier for walking if the knee is straight rotation is prevented by moulding the plaster closely to the sides of the thigh just above the knee as the plaster is setting (fig. 209a). A layer of stockinette is first threaded on the leg and then a layer of plaster wool is wound on evenly and tightly. Only in this way can a snug fitting plaster be obtained.

The child is encouraged to walk in the plaster; it remains on for six weeks when displacement has had to be corrected. After the plaster is removed the child quickly regains normal use of the limb and she can be left to do this on her own.

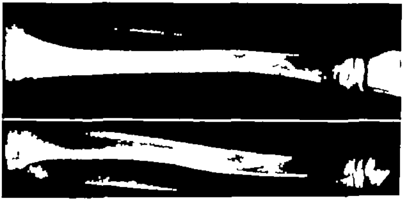


Fig 207b Eighteen months after the injury

Fig 207a Spiral fracture of the right tibia in a child

Fig. 208 Oblique fracture caused by tapping force (*left*) immediately after the injury (*right*) twelve weeks later

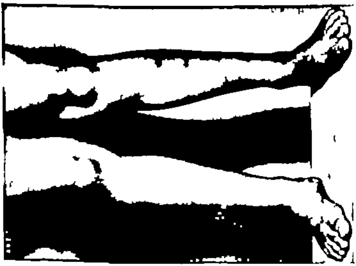


Fig 207*c* Patient of figs. 207 *a* *b* eighteen months after the injury

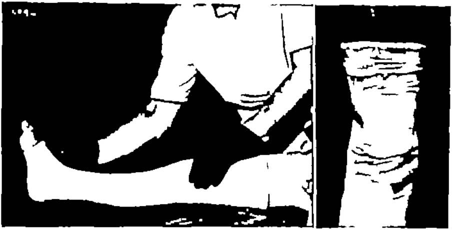


Fig. 209a. Moulding the long plaster cast around the femoral condyles.

Fig 209b Moulding the top and bottom of the short gaiter plaster

**FRACTURE OF THE SHAFT OF THE TIBIA IN AN ADULT

The bone is struck at right angles by a tapping force, i.e. a force acting with dying momentum on a small area. For example, a man is kicked by a horse.

The tibia breaks transversely (fig. 1) or slightly obliquely (fig. 208) at the point of impact. Displacement is slight, there is perhaps a little shift but nothing more. The skin is often split horizontally over the site of the fracture. The cut may need a suture or two but the subcutaneous tissues have not been crushed and there is no devitalised tissue to call for a wound toilet operation.

Reduction

Since the only displacement is a slight lateral shift, which is difficult to correct except at open operation, reduction is not attempted.

Splintage

A plaster cast, holding the knee just short of full extension and the foot plantargrade, is applied from the middle of the thigh to just proximal to the metatarsal heads. The patient is got up at once and made to walk, taking weight on the leg.

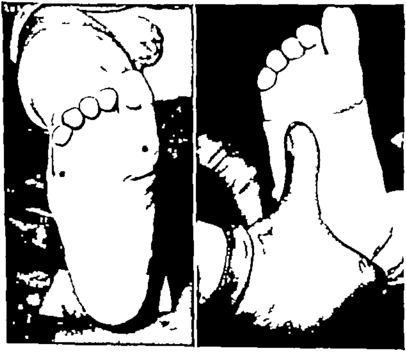


Fig. 209c (*left*) Heads of the metatarsals not covered by plaster. (*right*) thumb pressing behind the heads of the metatarsals.

Protection

The fracture is not united under twelve weeks, and even at the end of that time union is not strong enough to prevent angulation or refracture if the patient walks without protection. Plaster must therefore be retained for another twelve weeks. If the fracture is in the middle of the shaft a plaster gaiter gives enough support. This is put on over stockinette only and extends from below the knee to just above the ankle. As it is setting it is moulded around the expanding ends of the tibia above and below: unless this is done the plaster serves no useful purpose. The plaster leaves the knee and ankle free (fig 209b)

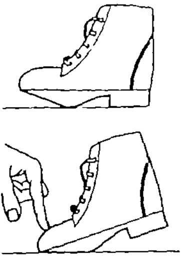


Fig 210. Rockered plaster overboot.

Treatment of the soft parts

After any fracture of the lower limb the patient should be got up walking as soon as possible. A person can walk reasonably well in a full length plaster provided that the foot is plantargrade and that the plaster is fitted with a rockered sole. *Plantargrade* means a position of the foot suitable for standing. The ankle should be at a right angle, i.e. the heel should be on the same level as the forefoot. More important, the heel and the forefoot should be neither in valgus nor in varus, i.e. the heel should be square and the ball of the big toe should be on the same level as the ball of the little toe. It is a common error to invert the forefoot so that the big toe is on a higher level than the little toe. Unless the big toe can reach the ground when in the standing position, normal walking is not possible. The metatarso-phalangeal joints should never be included in a plaster (fig 209c).

A leather boot is made to fit over the plaster. This has a heel, and the sole is rockered in order to compensate for the absence of mobility at the ankle joint (fig 210).

The patient is first taught to balance on his two feet. He can best learn this

Fig. 211 First stages of rehabilitation, standing on two legs holding the rail of the bed, and balancing on one leg. The patient is wearing a plaster overboot.

by himself by hanging with both hands on to the footrail of the bed (fig 211). Next, he is taught to balance on one foot. This is the most important part of his training The physiotherapist stands in front of him supporting his weight with her two hands in the axillae. The patient puts his hands on top of the physiotherapist's shoulders. He is told to hang on tight and to lift one leg off the ground, first the bad leg and then the good leg To begin with, the patient has no idea how to balance his body weight over his supporting leg Soon he learns to shift his weight over the supporting leg by abducting the hip on that side. Thereafter it is plain sailing It is wrong to try and get a man to walk before he can balance on his broken leg Directly he begins to get the knack of balancing he is made to lift the opposite knee to a right angle This makes balancing more difficult. After marking time successfully the patient is allowed to take short steps, putting the bad foot down four inches in front of the good foot and then deliberately advancing the good foot the same distance in front of the bad foot. In this way the patient learns to take equal weight on the two legs and a limp is avoided.

The patient is never allowed to pivot on his heel. And if at any time the patient is seen to limp or to walk incorrectly he should be sent back to bed and only allowed up under the eye and instruction of the physiotherapist.

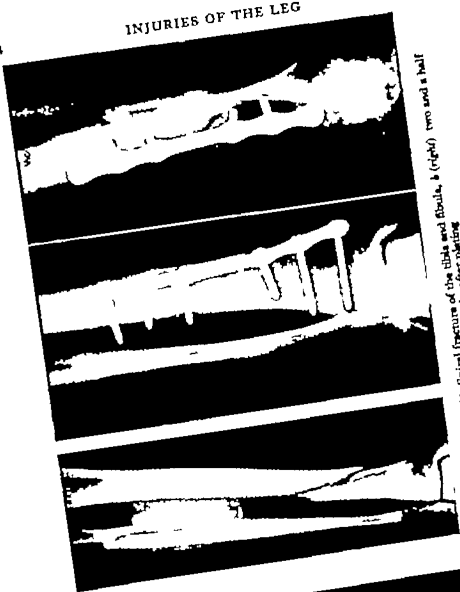


Fig. 213 a (*left*), Spiral fracture of the tibia and fibula, b (*right*) two and a half months after plating

Fig. 212 Tapping fracture of the shaft of the fibula.

Treatment by internal fixation

The ease with which a transverse or oblique fracture of the tibia can be plated affords an alternative method of splintage. At open operation exact anatomical reduction can be obtained and after the wound has healed the patient need only wear a plaster gaiter Since all his joints are free he quickly learns to walk normally A clerk is able to return to work within four weeks of his accident.

* FRACTURE OF THE SHAFT OF THE FIBULA

This is not a common or an important fracture. It is confined to adults and is caused by a tapping force for example a kick on the outer side of the leg The bone is broken transversely at the site of the impact. Since the tibia is intact there can only be slight displacement at the most a little sideways shift.

The patient is usually able to stand The skin may be breached and the local swelling makes it difficult to feel the fibula so that one relies on the radiograph for a diagnosis (fig 212)

Treatment

Reduction is not required, nor is splintage because the muscles can be relied on to safeguard the fracture site from harmful stresses, and protection is not needed because the intact tibia shields the fibula. So that, qua fracture, the injury does not require any treatment. As soon as the damage to the soft parts allows, the patient is got up and taught to walk without a limp

** SPIRAL FRACTURE OF THE TIBIA AND FIBULA

This is caused by a twist of the leg and commonly follows a simple fall The tibia breaks in its lower third and the fibula in its upper third (fig 213a) There is lateral shift, overlap and external rotation of the lower fragments. In a child the fibula remains intact as a rule, and the displacement is less and treatment is in consequence far simpler (fig 207a).

Reduction

Overlap and rotation are easily reduced by manipulating the lower part of the leg Lateral shift frequently defies reduction. Luckily this is of no consequence, for a lateral shift does not give rise to any disability

Splintage

Continuous traction is required to hold reduction of the overlap Traction also holds rotation.

A Steinmann's pin is passed transversely through the lower part of the tibia, or through the os calcis if the fracture in the tibia is low (figs. 214a, 214b) While the patient is under the anaesthetic the leg is rotated in to correct any external rotation. A weight of 10 lbs. is used, and the end of the bed is raised

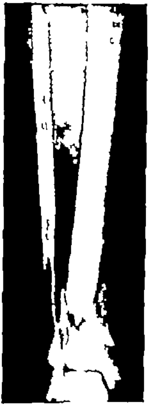
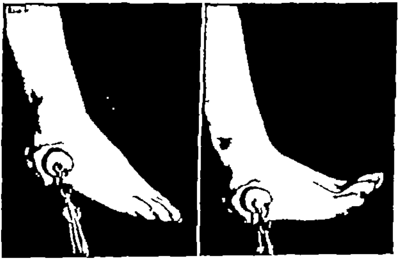


Fig. 214. *a* (*right*) Spiral fracture of the tibia treated by skeletal traction through the os calcis; *b* (*below*) patient exercising his ankle a week after the injury



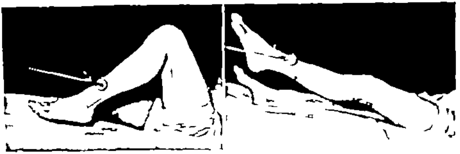


Fig 215 Skeletal traction through the lower third of the tibia.

10 inches to give counter traction. The leg is cradled on a pillow placed longitudinally: this holds the knee slightly flexed, which is comfortable for the patient and prevents the heel from pressing on the bed.

The 10 lbs weight remains on for six weeks. During this time the soft parts are treated energetically. The patient is taught to move his toes, ankle and knee, and to lift his leg off the bed in spite of its being anchored by the weight (fig 215). The patient is also taught to lift his trunk off the bed by hauling on an overhead rope, and also to move himself up in bed by dragging his leg with its attached weights after him. The nurse is warned that on no account are the weights to be lifted. Union takes six weeks and traction must be maintained all this time if overlap is to be avoided.

Protection

At the end of six weeks the weights are taken off and the pin withdrawn. Often the pin is loose and no anaesthetic is required for its removal. A skin tight plaster gaiter is applied reaching from below the knee to above the ankle. This gaiter remains on for another six weeks, making three months in all from the time of the accident.

Where good facilities exist plating the fracture shortens the period of recumbency (fig 213b). Operation however is not imperative nor so beneficial as in the transverse fracture.

** TRANSVERSE FRACTURE OF THE TIBIA AND FIBULA

This is a common fracture in men in the prime of life. It does not often happen to children or to old people. It is caused by four kinds of force and each produces its own kind of fracture. With a tapping force (for example a kick on the shin) both bones break transversely at the same level at the point of impact (fig 216). With an angulating force (a motorcycle accident) both bones break trans-

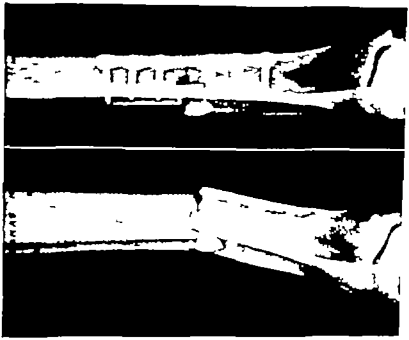


Fig. 217 Fracture of the tibia and fibula caused by an angulation force. Plated within a few days of the injury

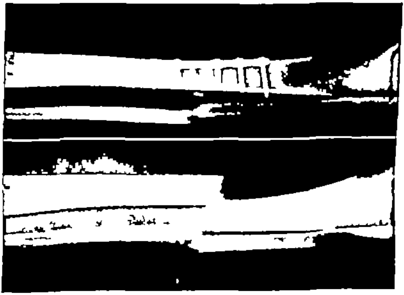


Fig. 216. Tapping fracture of the tibia. Skin over the calf cut. Plated fourteen days later

ensely at the same level about the middle of the shaft and the antero-posterior radiograph often shows a characteristic triangular third fragment (fig 217). With a crushing force, i.e. a force of great momentum acting over a wide area, the bones break more or less at the same level at the site of the crush and often in several places with widely scattered fragments. When the wheel of car runs over a limb a crushing force is combined with a rolling force. The effect on the bone is the same as for a simple crushing force but the effect on the skin is different.

The soft parts are more liable to damage in a transverse fracture of the tibia and fibula than in any other fracture. The type and degree of damage is different in the four kinds of fracture.

In a *tapping fracture* the skin is cut cleanly and the underlying tissues are not badly hurt. In an *angulation fracture* the skin may be punctured from within by the sharp end of one bone. Tissues deep to the skin are not devitalised. In a *crush fracture* there is a jagged cut in the skin and the underlying muscles are severely damaged. In a *run-over fracture* there is the same damage to the muscles but the skin suffers much more severely The rolling force tends to flay the skin and a large flap may actually be raised. There may be no breach of the skin, nevertheless the skin may have been forcibly pulled away from the deep fascia and its blood supply cut off In this event a large area of skin is doomed to die.

After widespread damage to muscles and skin it is unwise to encase a limb in plaster and even more unwise to plate the bone forthwith. Therefore on account of the damage to the soft parts two treatments are envisaged for a fracture of the tibia and fibula—a *provisional treatment* to tide over the period when plastering and plating are undesirable; and a *definitive treatment* for when the danger period has passed.

Provisional treatment

The bone, the skin, and the muscles require separate consideration.

As regards the treatment of the bone, in the tapping fracture it is safe, in the angulation fracture it is fairly safe, in the crushing fracture quite unsafe and in the runover fracture disastrous to start definitive treatment straight away It is probably better in *all* fractures of the tibia and fibula to apply skeletal traction through the os calcis and let the leg rest in bed on a pillow (fig 218). Ten lbs. weight is used and the foot-end of the bed is raised 10 inches This amount of traction restores alignment to the leg and makes the patient comfortable. Until the skin has healed and the reaction of the soft tissues to the trauma has subsided it is unwise to do anything more.

As regards the muscles, nothing active can be done except to prevent infection of the traumatised tissues. Infection is not to be feared unless the skin has been breached. If it has, a wound toilet (page 40) should be done.

The skin deserves most consideration. If it is cut, it should be sewn up When there is a loose flap it is often difficult to tell whether the skin will live. As a general rule, whenever the base of the flap is not as broad as its length the

flap of skin is cut away and the denuded area covered with a split-skin graft. When there is doubt whether the skin is viable, it is left but is kept under close observation. The runover injury presents the most difficulty for it is not obvious at first how much skin has been devitalised (fig 22 page 44). Leaving dead skin *in situ* is an invitation to sepsis.

To sum up in a *tapping fracture* the skin if cut is stitched, but a wound toilet should not be done. In an *angulation fracture* the punctured skin hole may be disregarded, and a wound toilet operation is not necessary In a *crushing fracture* if the skin is broken a wound toilet should be done. In a *runover fracture* a flap of skin is cut away and replaced by a split-skin graft or sewn up according to the surgeon s estimate of its chance of survival. And the area is inspected daily any skin that goes black is immediately excised and the raw area covered with a graft.

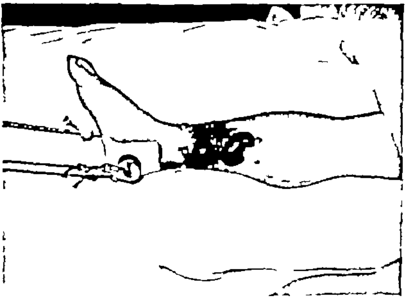


Fig 218. Crush fracture of the tibia and fibula. Provisional treatment by skeletal traction.

Definitive treatment

When the fracture is ready for definitive treatment the surgeon has a choice of several methods. skeletal traction, plaster cast or plating

Skeletal traction (fig 219). When the state of the skin prohibits plating and when it is unwise to hide the skin under plaster skeletal traction is the only treatment available. Traction secures alignment but it does not reduce overlap unless the weight is excessive and traction to that degree leads to fibrous union instead of to bony union. Moreover traction does not by itself control rotation in a transverse fracture.

Plaster cast The cast extends from the middle of the thigh to just proximal to the metatarsal heads (fig 209a) The patient is anaesthetised and the pull is temporarily interrupted. The leg is acutely bent at the site of the fracture and the ends apposed and then straightened Traction is now reapplied by an assistant, who pulls with all his might on the end of the traction strings. While he is pulling in this manner a plaster cast is applied. The patient goes back to bed with 10 lbs traction on An X ray is taken in a day or two and if this shows that the ends of the bones are hitched traction is discarded and the pin is removed from the os calcis. If the bone ends are not end-on the traction is retained.

Union cannot be expected under twelve weeks. If the leg gets loose inside the plaster or if the sole of the plaster gets soft it may be replaced but not under six weeks from the reduction. After any change of plaster the position should be checked by X rays. The second plaster is put on without an anaesthetic and should be skin-tight. At the end of twelve weeks the long plaster is removed and an X-ray taken. If the radiograph shows satisfactory callus and if the ankle dorsiflexes to a right angle a plaster gaiter is applied, from just below the knee to just above the ankle. When however the ankle does not dorsiflex to a right angle and when callus is scanty the foot must be included in the new plaster otherwise a backward angulation stress falls on the fracture site when the patient walks and the bone refractures. This happens without the patient s knowledge, and as he continues to walk non union ensues. It is six months before a transverse fracture of the tibia and fibula is consolidated.

Plating the tibia (fig 220) Besides shortening the period of disability this treatment has two advantages. It ensures anatomical reduction. And the leg can be left free in bed after the operation until the ankle and tarsal joints have regained full mobility This takes place in about a fortnight. A short plaster (fig 209b) reaching from below the knee to proximal to the metatarsal heads is then worn for four weeks, and in this plaster the patient is made to walk. At the end of six weeks from the operation the plaster is changed for a plaster gaiter reaching from below the knee to above the ankle. The gaiter is kept on until the patient is walking normally The patient is able to return to work in three months from the accident with perfect alignment and with full movement of all joints.

Complications

Osteomyelitis If this occurs it is wise to remove the Steinmann s pin. The fracture is held in alignment by a plaster which is windowed for dressing the wound. The plaster gets soft and filthy from the discharge from the wounds, and may require frequent renewals. Sepsis delays union and nothing can be done to hasten union while a sinus remains unhealed. The doctor must continue patiently to hold the fractured ends in alignment in plaster The patient will not be able to get up and the leg is too painful for muscle activity so that

Fig. 219 *a* (*top*) Crush fracture of the tibia and fibula, *b* (*below*) being treated by skeletal traction. *c d e f* on pp. 313–14.

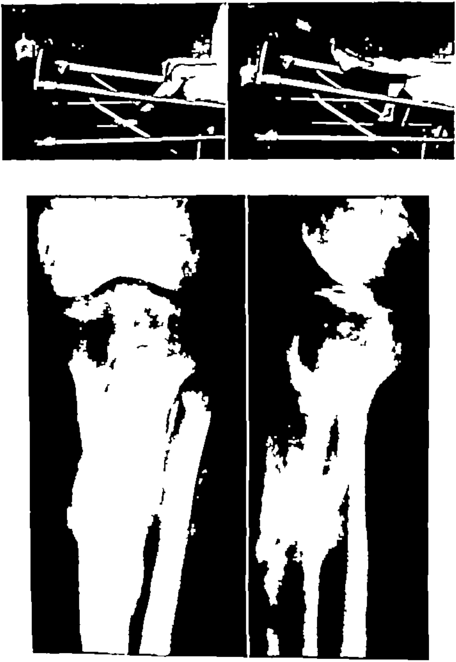


Fig 219 c (top), Exercising the knee; d (below) four weeks after the injury

Fig. 219. *a* (*top*) Crush fracture of the tibia and fibula; *b* (*below*) being treated by skeletal traction. *c d*, *e f* on pp. 313–14.

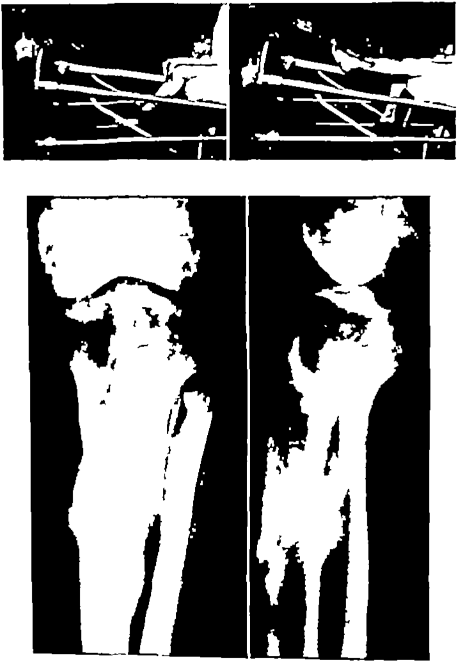


Fig 219 c (top), Exercising the knee· d (below) four weeks after the injury

Fig. 219 *e* (*top*) Taking weight three months after the injury. *f* (*below*), range of movement.

the stimulus for repair is lacking Also the ensheathing callus disappears in the presence of sepsis. Non-union is therefore a common sequel.

Malunion This also is common. Overlap is of little importance in a man, for it does not cause any loss of function and an inch of shortening is scarcely noticed. In a woman overlap alters the contour of the leg and should be avoided if possible Backward bowing is very common, it limits plantar flexion at the ankle but this causes little inconvenience. Inward bowing gives rise to disability because the line of the bodyweight is no longer transmitted through the ankle joint at a right angle, and in consequence the ligaments on the medial side of the ankle are under constant stress whenever the patient stands. It must be remembered when reducing the fracture that the tibia is not a straight bone but has a natural outward bow and this bow must be restored. Continuous traction straightens the tibia and destroys the natural curve. This is one of the reasons why traction should be discarded as soon as possible. Internal rotation of the lower fragment is common and is disabling because the knee and the ankle joints no longer work in the same plane. When the first plaster is being moulded care should be taken that the patella and the foot point in the same direction. One is apt when restoring the natural outward bow of the tibia to rotate the lower part of the leg inwards.

Non-union. This is common with a transverse fracture and rare with a spiral fracture Faulty treatment is usually to blame. The fibula unites quickly and the union prevents the two ends of the tibia from impinging on one another and thereby removes the stimulus to union by bone. For this reason the patient is taught early to contract the muscles of the foot; for with each contraction the lower fragment of the tibia is pulled against the upper fragment. Traction also removes the stimulus for repair by bone, and this is an additional reason for dispensing with traction as soon as possible.

When the fracture is open the haematoma round the fractured ends drains away and the ensheathing callus is small in amount. In consequence union will be delayed. Unless this is realised the plaster is removed too soon and the tibia refractures.

Another cause of non-union is splinting the ankle in equinus. When the plaster is removed and the patient walks he cannot get his sole on the ground without hyperextending his knee or angulating backwards at the fracture site. The union breaks. The patient and his doctor are unaware of what has happened and the patient continues to walk. And non union develops because the hinging stress stimulates repair by fibrous tissue instead of repair by bone.

Oedema of the leg This troublesome complication rarely occurs if the patient is never allowed to forget that he has a leg and uses his muscles from the beginning It is common if the patient does not use his muscles and, when on crutches carries his leg like a log Should it occur the leg is compressed by means of an elastic bandage. The swelling subsides slowly

Stiff painful foot This is the commonest complication, and results from neglecting to treat the soft parts.

* LONGITUDINAL FRACTURE OF THE TIBIA

This is an uncommon fracture met with in adults as the result of a fall from a height. Three or four fracture lines run longitudinally up and down the shaft (fig 223) There may be a spike completely separated and occasionally the bone is also broken transversely As a rule, however the fracture is incomplete.

Treatment

Reduction is not necessary unless there is a transverse fracture as well (in which case the injury is treated as a transverse fracture). The leg is encased in a plaster cast from the middle of the thigh to the toes. This holds the knee straight and the foot plantargrade. As soon as the patient can lift his leg off the bed he is got up and taught to walk, taking weight on the leg

Often plaster is not necessary because the fracture is incomplete. At first it is surprising that the patient can take weight so soon, but on second thoughts it is to be expected that a bone that has not buckled under the excessive longitudinal stress of a fall from a height should stand up to the stress of weight bearing The plaster in any case can be discarded in six weeks

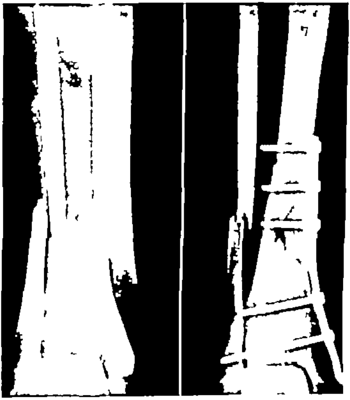


Fig. 220 Tapping fracture of the lower fourth of the tibia. Treated by plating

Fig. 221 *a* (*left*) Crush injury causing several fractures of the tibia and fibula. Treated by preliminary traction and then a plaster cast. *b* (*right*) two years later

Fig. 222. *a* (*left*) Crush injury causing several fractures of the tibia and fibula, *b* (*right*) the medial malleolus has been pinned, and one fracture has been plated. Then a plaster cast was applied. *c* (*opposite*)

Fig. 222c fourteen months later

Fig 223 Longitudinal fracture of the tibia.

Fig 224 Two views of a normal ankle showing the difficulty of deciding whether the talus has been displaced unless a truly lateral view is obtained.

31

Injuries around the Ankle

** DISLOCATIONS OF THE ANKLE

Dislocations and subluxations of the ankle without an associated fracture are rare.

UPWARD DISLOCATION

Sometimes after a fall from a height the talus is displaced upwards. The tibia separates from the fibula after rupture of the tibia fibular ligaments, and the talus, carrying with it the foot, rises between the two bones (fig 233).

Reduction is easy Three months splintage is necessary to obtain sound healing of the tibio-fibular ligaments. Alternatively the tibia can be firmly secured to the fibula by a screw passed horizontally from the lateral to the medial side

FORWARD DISLOCATION OF THE TALUS

Sometimes as a result of an aeroplane crash the talus dislocates forwards, the tibia and os calcis remaining in their normal position. The mechanism is not clear It is thought to occur when the foot is excessively plantarflexed.

The talus forms a lump under the skin. Reduction is needed urgently because the skin quickly sloughs from the pressure of the bone beneath it. Reduction may be difficult; nevertheless the talus should not be removed if it can be helped. The prognosis is said to be good after a successful reduction this is strange, for one would expect aseptic necrosis to follow every time.

MEDIAL DISLOCATION

This is a rare injury The talus and the foot with it, passes to the medial side of the medial malleolus.

FRACTURE SUBLUXATIONS OF THE ANKLE (POTT'S FRACTURE)

The description given by Pott is too indefinite for the fracture he described to be identified. Fractures about the ankle are very common and are of many kinds, and it is useful to gather them all together under the generic term Pott's fracture.

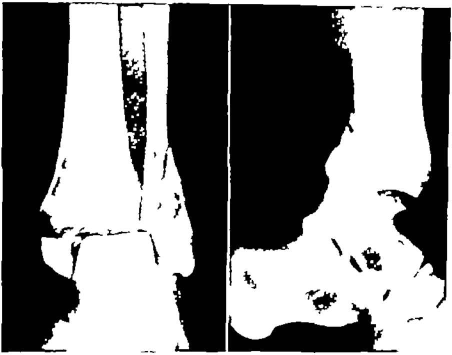


Fig 225 Lateral-rotation Pott's fracture. Lateral shift, slight lateral tilt, and posterior shift.

Fig 226 Lateral-rotation Pott's fracture Lateral shift, lateral tilt. Reduction held by screwing the medial malleolus to the shaft.

Fractures about the ankle are usually associated with a subluxation of the ankle joint—a subluxation, not a dislocation. In a dislocation the bone ends are apart, in a subluxation the ends are in contact but the articular surfaces are not accurately opposed

A Pott's fracture is a double injury: a fracture and a subluxation. The subluxation is by far the more important because if the articular surfaces of the tibia and talus are in normal relationship any fracture is automatically reduced. The reduction may not be anatomically perfect but it is sufficiently good not to cause any subsequent disability In the treatment of a Pott's fracture the doctor concentrates on the reduction of the subluxation. To reduce a subluxation a force must be applied opposite to the force that caused the subluxation It is necessary therefore to know the direction of the damaging force and Pott's fractures are best classified on that basis.

On reduction of the subluxation the fractures are automatically realigned. It follows that when there has not been any subluxation reduction of the fracture is not required. Some patients with fractures of the ankle need no treatment other than rehabilitation Their fractures are left to look after themselves, and they are got up without any splint.

Since the subluxation and not the fracture is the important factor the doctor when viewing the radiographs disregards the displacement of the fractures and concentrates on the displacement of the talus. The displacement may be only slight and may be overlooked by the inexperienced In the front view of a normal ankle the space separating the side of the talus from the medial malleolus is the same as that separating the upper surface of the talus from the tibia (fig 226) When the talus has shifted laterally—the commonest displacement—the space between the talus and the intact portion of the medial malleolus is increased. When the medial malleolus is fractured the lower fragment clings to the talus and moves with it. Also in the front view the upper surface of the talus is normally parallel to the surface of the tibia. Often the line of the tibia is wavy: if so the undulations exactly fit similar undulations on the talus. In the lateral view the curve of the upper surface of the talus should be parallel to the curve on the tibia. If the X ray is not strictly lateral the talus and the tibia each show two curves and it is more difficult to decide whether the talus and the tibial platform are parallel (fig 224). In a Pott's fracture the talus is sometimes subluxated backwards, carrying with it the foot; this is the displacement that the doctor is on the look-out for in the lateral view

It is convenient to group Pott's fractures according to the direction of the force causing them, thus. lateral rotation, abduction, adduction shearing and vertical fractures are recognised The particular group i e the causative force can be ascertained from the radiographs by observations on the site and direction of the fracture lines. In the *lateral rotation fracture* the line of fracture through the fibula runs spirally upwards and backwards from the level of the joint mortice. In the *abduction fracture* the fibula breaks transversely two or

Fig 227 Lateral rotation Pott's fracture Front view deceptive

three inches up the shaft. In the *adduction fracture* the fibula often escapes injury but the medial malleolus splits off from the shaft above the level of the mortice In the *shearing fracture* both malleoli break at the level of the mortice In the *vertical fracture* the lower end of the tibia is broken transversely and a vertical split runs down from this fracture into the ankle joint.

* LATERAL ROTATION FRACTURE SUBLUXATION OF THE ANKLE

This is the commonest type of Pott's fracture. It is caused by rotation of the foot outwards and backwards. The usual history is that the patient unexpectedly stepped off the pavement into the gutter

An oblique fracture runs through the lower end of the fibula commencing at or below the level of the ankle mortice in front and passing backwards and upwards (fig 225) The medial malleolus may also break transversely below the level of the ankle mortice. Often there is a third fracture, which is seen in the lateral view as a triangular fragment split off the posterior part of the tibia. The lower fragment of the fibula is slightly displaced backwards in most cases,

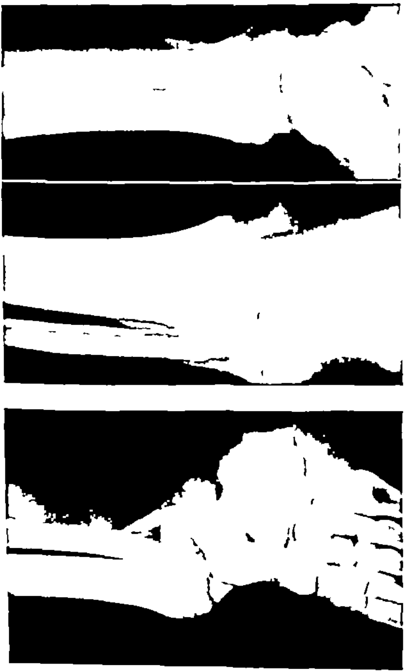


Fig 228 *a* (*left*) Lateral rotation Pott's fracture Gross displacement *b* (*right*) after reduction.

Fig 229 Lateral rotation Pott's fracture: *left*, slight lateral shift, slight lateral tilt; *right* reduced by rotating the foot in.

but this is of no consequence. When displacement is spoken of it refers to the position of the talus as regards the mortice.

In the front radiograph two displacements are looked for. The talus may be *shifted laterally* (fig 226). The gap between the talus and the medial malleolus ordinarily measures the same as the gap between the upper surface of the talus and the tibia. The talus may also be *tilted laterally* (fig 226). The upper margin of the talus is normally parallel to the lower margin of the tibia. In the lateral radiograph the talus may be *shifted backwards* (fig 227): the curve of the upper *margin of the talus then no longer corresponds with the curve of the tibia.* A true lateral picture is necessary to be sure about this, an oblique view is of little help (fig 224). Sometimes the antero-posterior radiograph shows a space between the lower end of the fibula and the lower end of the tibia. The presence of this diastasis does not make any difference to treatment, for the interosseous ligament repairs satisfactorily while the leg is in plaster (fig 231).

Signs

When there is gross displacement the diagnosis is obvious on sight, for the foot is lying on its outer side (fig 228). Usually however the ankle appears normal except for swelling. There is tenderness over the lower inch of the fibula and over the lower end of the medial malleolus. It is kinder to rely on the radiograph for an exact diagnosis rather than to submit the patient to a painful clinical examination.

Treatment when the talus has not been displaced

When the radiograph shows the talus in its normal position and one can be sure that it never has been out of position, splintage is not necessary. The patient is allowed up without any support and is taught to walk. Within a week

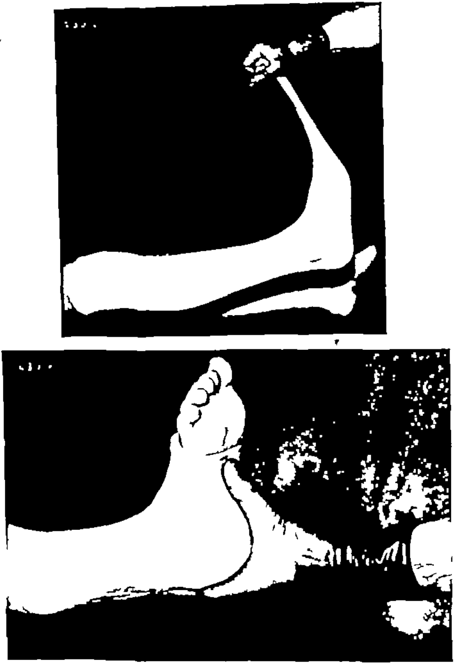


Fig 230 *a* (*top*) Holding the foot at a right angle by means of the stockinette. *b* (*below*), Holding the foot plantigrade while the plaster is setting

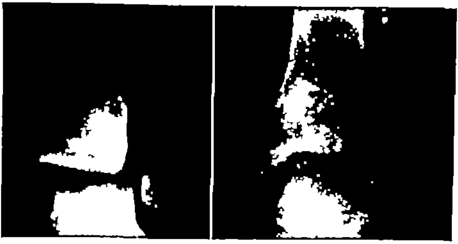


Fig 231 Lateral rotation Pott s fracture. Unusually high fracture Treated by a routine plaster cast. Three months interval. The diastasis was immaterial

he should be walking without a limp If he is not, the position of the talus should be checked by an X ray it may have displaced in the meantime. This check by X rays at the end of a week is essential because the talus may have been reduced by a first aid worker or may have reduced itself

Treatment when the talus has been displaced

When the talus is out of position, as shown by radiographs, it must be replaced. Whatever the degree of displacement the method of reduction is the same. Under anaesthesia a piece of stockinette is threaded on to the leg to about the middle of the thigh, and the leg is suspended in mid-air by the lower end of it (fig 230a) This automatically reduces any backward displacement. While the leg is being held in the air the lateral shift and lateral tilt are corrected by placing one palm on the outer side below the ankle and the other palm on the inner side above the ankle and rotating the foot medially (fig 229). Once reduced the talus remains in position The assistant continues to suspend the leg by the stockinette while the surgeon applies a circular plaster from below the knee to the toes. This holds the foot plantargrade. The plaster is applied rapidly and then the foot is allowed to rest on the table with a roll of plaster wool behind the ankle so that the heel does not touch the table. While the plaster is setting the surgeon moulds it round the ankle and under the transverse arch. Care should be taken to get the foot plantargrade and not inverted (fig 230b). The plaster should not include the metatarso-phalangeal joints, and all the heads of the metatarsals should be free of plaster (fig 230b).

Reduction should be checked by radiography The space between the medial malleolus and the talus shows whether reduction is perfect. Rarely the peroneal tendons get trapped inside the ankle joint and prevent reduction

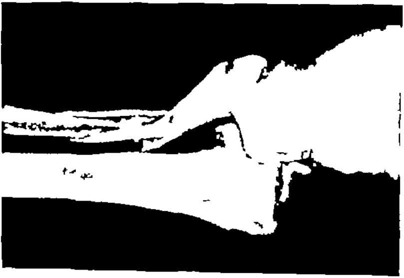


Fig 232 Abduction Pott's fracture.

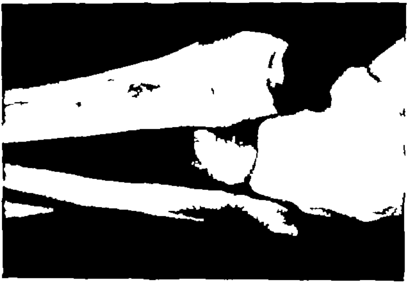


Fig 233 Dupuytren's fracture The talus has ridden up between the tibia and fibula.

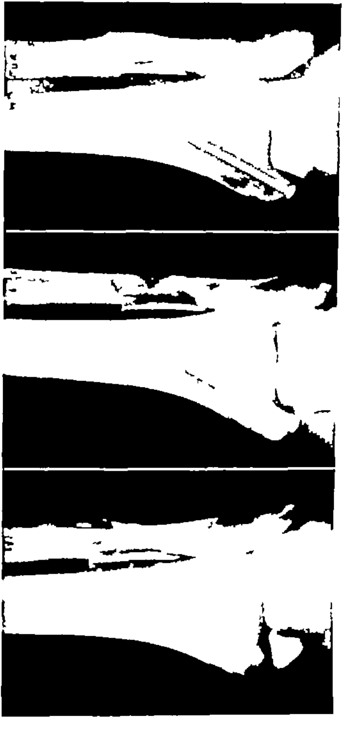


Fig 234. Abduction Pott's fracture Intervals two days, four months. No external splintage was employed.

although the correct manoeuvre has been applied. Open operation may then be necessary to extricate them from the joint.

The patient is made to move his toes, to attempt to move his ankle inside the plaster to lift his leg off the bed, and to straighten and bend his knee. A plaster boot is ordered and when this is ready the patient is got up and taught to walk taking weight on the foot It is of the utmost importance that the patient should walk properly using his toes to propel himself forward at each step

Union takes six weeks. At the end of that time the plaster is taken off. No further splintage is required because the fracture being spiral, angulation is not to be feared. If the patient has been walking well in plaster little further need be done. If the foot has been immobile the foot swells on removal of the plaster and many weeks pass before painless movement is regained.

Treatment by internal fixation

Any displacement of the talus however slight must be corrected, and if correction has been necessary the reduction must be held. This, as described above, is usually done by a plaster cast. But however active the patient is while in plaster some stiffness of the tarsal joints is present when the plaster is removed It would obviously be better if plaster fixation could be avoided. For this reason many surgeons now treat this fracture by internal fixation. Anatomically the talus is fixed to the medial malleolus by a strong ligament; this ligament usually remains intact, the medial malleolus breaking just above its attachment. By fixing the broken malleolus firmly to the shaft of the tibia the talus can be securely anchored in its normal position. It is easy to fix the medial malleolus to the shaft with a long vertical screw (fig 226) After the operation the foot is left free in bed and active movements are encouraged. When the stitches are out the patient is got up without external support and taught to walk. By this method of treatment convalescence is much reduced, for the tarsal joints never have a chance to get stiff

•ABDUCTION FRACTURE SUBLUXATION OF THE ANKLE

This is far less common than the lateral rotation fracture. It is caused by an angulation force, which hinges the ankle outwards. The fibula breaks transversely two or three inches up (fig 233) Often there is a separate small wedge-shaped fragment showing the nature of the causative force. The medial malleolus also breaks transversely below the level of the tibial platform.

It should always be assumed with an abduction fracture that the talus is displaced, indeed it is hard to see how the fracture can occur without the fibula separating from the tibia. There is nearly always a *lateral shift* and a *lateral tilt* but *backward shift* of the talus is unusual. At times the lateral shift is so

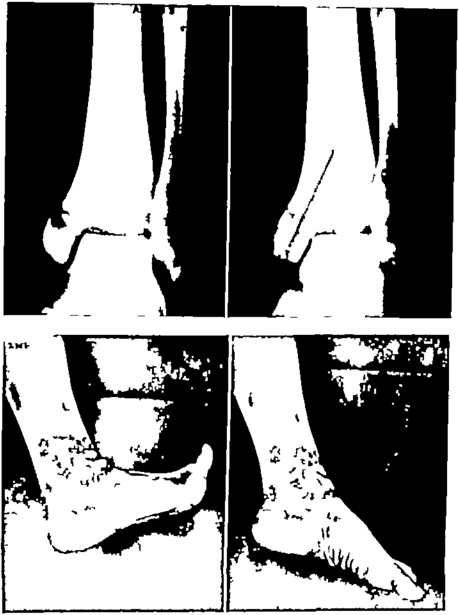


Fig 235 *a* (*top*) Adduction Pott's fracture. Screwed.
b (*below*) ankle movement ten days after the operation.

great that the talus rides up between the tibia and fibula, a fracture called in this country Dupuytren's fracture (fig 233)

Signs

The contour of the foot may not be unusual apart from the swelling around the ankle. Tenderness is present two to three inches up the shaft of the fibula and over the medial malleolus. Ankle movement may be possible but it is kinder to await the radiograph than to try to make an accurate clinical diagnosis

Routine treatment

Whether displaced or not, all abduction fractures are treated alike and are put through the manoeuvre of reduction It is not possible to over reduce, and minor degrees of displacement leading to loss of function are common.

Stockinette is threaded on to the leg as far as the middle of the thigh, and the foot suspended from the end of it. Then the patient is rolled over on to his side with the injured leg uppermost. A small round sandbag or wedge is placed under the leg at the site of the fracture, and the surgeon leans on the foot with the whole weight of his body and forcibly adducts it.

The patient is now rolled over on to his back and while an assistant lifts the leg off the table by holding the end of the stockinette in such a way that the foot is dorsiflexed to a right angle (fig 230a) the surgeon applies a plaster cast from below the knee to the toes. The plaster is put on rapidly and then the foot is allowed to rest on the table with the roll of wool underneath to prevent the heel from touching The surgeon moulds the plaster round the ankle and the transverse arch, then he places the palms of his hands, one on the outer side below the ankle and the other on the inner side above the ankle, and tries to push the ankle medially care being taken not to invert the foot. The lateral shift and the lateral tilt may have recurred during the application of the plaster and this manoeuvre ensures maintenance of reduction while the plaster is setting

The soft parts are treated as in the lateral rotation fracture. The patient is fitted with an overboot and is taught to walk without a limp

The plaster may require renewal either because the foot-piece wears through or because the plaster cracks above the ankle. The second plaster is unpadded. At the end of six weeks the plaster may be replaced by an inside T strap and an outside iron Abduction at the ankle region must be prevented by some form of splint for three months from the time of the accident since the fracture in the fibula is transverse and is therefore liable to angulate until it is consolidated

Treatment by internal fixation

The abduction fracture lends itself to internal fixation. When there is a fair sized medial malleolar fragment, screwing this to the shaft of the tibia anchors the talus in its proper position (fig 234). Some surgeons like to insert in addi tion a second screw transversely through the fibula into the tibia, half an inch

Fig. 236 Adduction Pott s fracture. Gross displacement. Ten weeks after screwing the medial malleolus.

Fig 237 Two shearing Pott s fractures, *left* adduction force *right* abduction force

or so above the mortice. The patient is allowed to walk as soon as the stitches are out, without any external support Convalescence is much shortened by this method of treatment.

Prognosis

Properly treated the abduction fracture repairs perfectly Malunion however is common, either from lack of proper reduction or from failure to hold reduction or from failure to protect for long enough. Malunion causes a painful ankle which may eventually require arthrodesis.

Another common cause of disability is stiffness of the tarsal and toe joints. This happens because the patient has not walked properly while in plaster but has used the leg as a peg, pivoting round on his heel.

The lateral rotation fracture is a pleasant fracture to treat; reduction is easy secondary malunion does not occur and only six weeks splintage is required. The abduction fracture is an unpleasant fracture; reduction is difficult, secondary malunion is common and splintage has to be maintained for three months

*ADDUCTION FRACTURE SUBLUXATION OF THE ANKLE

An adduction force applied to the ankle usually causes the common sprain of the ankle (which is in reality a sprain of the subtaloid joint). Sometimes the force causes in addition a fracture of the medial malleolus. The fracture line starts at the level of the mortice where the medial malleolus joins the horizontal portion of the tibial platform (fig 235a) It passes upwards and perhaps slightly medially to emerge from the medial side of the shaft about an inch higher up The tip of the lateral malleolus is often detached as it is in a sprain of the subtaloid joint.

Signs

There may be nothing about the appearance of the foot to distinguish it from other varieties of fracture subluxation or from a simple sprain. The doctor may be able to localise tenderness to the site of the fracture but it is kinder to await the radiograph for an exact diagnosis The radiograph shows the characteristic line of the fracture. Displacement as a rule is slight, but the talus may be shifted medially and tilted medially (fig 236). Posterior shift rarely occurs.

Treatment

Stockinette is threaded on to the leg up to the middle of the thigh, and the foot is suspended from the end of it. While the foot is suspended in this position the surgeon places one palm on the outer side of the foot above the ankle and the other palm on the inner side below the ankle and gently shifts the foot laterally and into valgus.

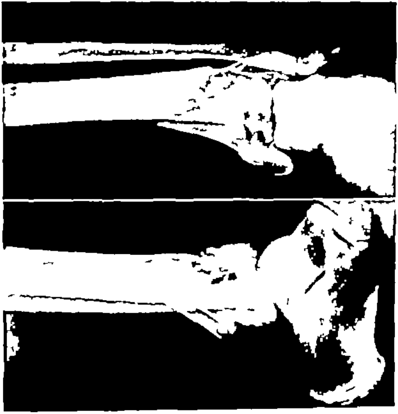


Fig 239. T-shaped fracture of the tibia into the ankle.

Fig 238. Lateral rotation Pott's fracture mimicking a shearing fracture

While the assistant is suspending the leg in mid air (fig 230a) in such a way that the foot is at right angles the surgeon applies a plaster cast from below the knee to the toes. The plaster is put on rapidly and then the leg is allowed to rest on the table with a roll of plaster wool behind the ankle to prevent the heel from touching the table. While the plaster is setting the surgeon moulds the plaster round the ankle and under the transverse arch of the foot.

The soft parts are treated as in the other varieties of fracture subluxation of the ankle. *The patient is fitted with an overboot, and is taught to walk without a limp*

Union cannot be expected under twelve weeks; but since it is easy to prevent adduction of the ankle by an outside T-strap and an inside iron this may be substituted for the plaster in six weeks. It should be worn for another six weeks

Prognosis

Reduction is simple and secondary malunion can easily be guarded against. Recovery should be perfect.

Treatment by internal fixation

The adduction type of Pott s fracture in particular lends itself to internal fixation. The medial malleolus forms a large separate fragment which can easily be fixed to the shaft of the tibia by a screw (figs. 235 236) External splintage is then dispensed with and the patient recovers from his injury to all intents and purposes in three weeks from the accident.

* SHEARING FRACTURE SUBLUXATION OF THE ANKLE

This is an uncommon fracture caused by a horizontal force striking the ankle from the lateral or medial side. Both malleoli are fractured transversely at the level of the tibial platform (figs. 237 238) There are no distinctive signs. This variety of Pott s fracture may be open

Treatment

As the foot can be shifted anywhere, reduction is easy but it is difficult to know when the talus is in the socket The foot must *not* be suspended by stockinette because the talus shifts forwards as easily as it does sideways. A plaster cast is applied from below the knee to the toes, with the foot plantargrade. The surgeon moulds the plaster round the ankle, holding the talus in the mortice. If the radiograph afterwards shows the talus in its normal position the usual treatment for the soft parts is proceeded with The patient is fitted with an over-boot and taught to walk without a limp

Union cannot be expected under three months, and splintage must be continued for this length of time. The plaster may be replaced by side irons at the end of six weeks.

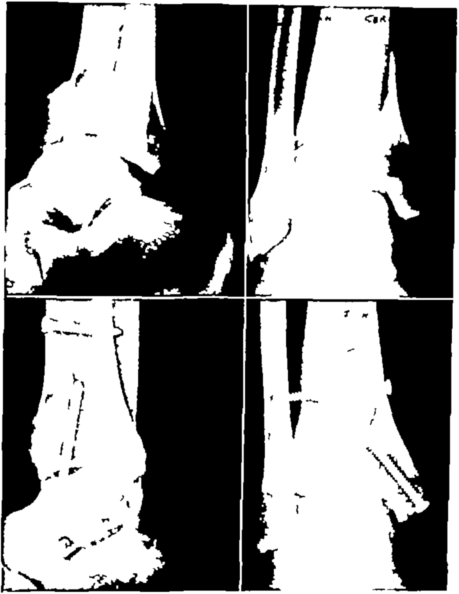


Fig. 240. T-shaped fracture of the tibia into the ankle. Open reduction. Reduction held by three screws.

Treatment by internal fixation

Since there is no fixed point to act as a buffer against which the talus can be pushed, reduction is often inaccurate. For this reason and in order to shorten convalescence it is better to screw the medial malleolus to the shaft of the tibia After the operation it is often safe to get the patient up without external support, but it is probably wise to put the leg and foot into plaster for six weeks.

*** T SHAPED OR VERTICAL FRACTURE SUBLUXATION OF THE ANKLE

This is caused by a force acting in the line of the shaft of the tibia, and the usual history is a fall from a height. The tibia is fractured one inch or so from the ankle. In addition there is a vertical coronal split running up from the middle of the mortice to join the transverse fracture (figs. 239, 240 241). There is not much displacement at the horizontal fracture, but the fragments below are rotated and shifted on one another in any direction when, as often, the end of the tibia is in many fragments The talus accompanies one or other of the two main halves of the tibia.

Treatment

Accurate reduction is difficult if not impossible, even at open operation (fig 240) In all probability the tibial mortice will not again fit the talus and the opposing articular surfaces will be incongruous. The best hope comes from getting the ankle to move relying on the unbroken articular surface of the talus to mould the fragmented tibial platform. A Steinmann s pin is passed through the os calcis transversely and a weight of 10 lbs. applied The end of the bed is raised 10 inches to give countertraction The leg is cradled on a pillow On the day after the accident the patient is encouraged to start moving his ankle. Traction is retained for six weeks. After that time the patient may get up but he should not bear weight for another six weeks (fig 241)

Unless the fragments forming the mortice can be accurately fitted together the ankle joint does not wear well, and although the immediate result may be an ankle with half the normal range of movement, osteoarthritis is a probable sequel.

* FRACTURE SEPARATION OF THE LOWER EPIPHYSIS OF THE TIBIA

A force which in the adult causes a Pott s fracture, i.e. a fracture-subluxation of the ankle, causes in the child a fracture separation of the tibial epiphysis (figs. 242, 243) Displacements occur corresponding to the lateral rotation abduction and adduction fractures of the adult. And treatment is in principle the same. Repair however is quick, and usually six weeks in plaster is sufficient for any type of fracture. Secondary malunion does not happen.

Subsequent interference with growth is not uncommon. When the medial half of the epiphysis does not grow as quickly as the lateral half the ankle mortice tilts into varus. The varus deformity of the ankle cannot be masked by the subtaloid joint because the subtaloid joint cannot swing into valgus. To make the foot plantargrade the tibia has to be osteotomised just above the ankle after the removal of an inch or so of the fibula.

When the lateral half of the epiphysis does not grow as quickly as the medial half the ankle mortice tilts into valgus. But a valgus deformity at the ankle can

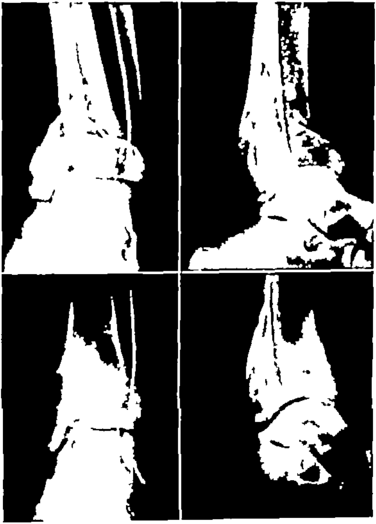


Fig. 241a T-shaped fracture of the tibia into the ankle Treated by skeletal traction and movement. *b* (*opposite*)

be masked by a varus at the subtaloid joint so that the foot appears normal in shape and the irregularity of growth is only diagnosed by a radiograph Since the foot is plantargrade no treatment is necessary

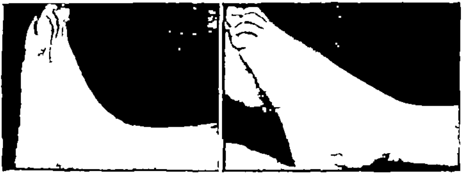


Fig. 241b range of movement at the ankle.

Fig 242 Fracture-separation of the lower end of the tibia.

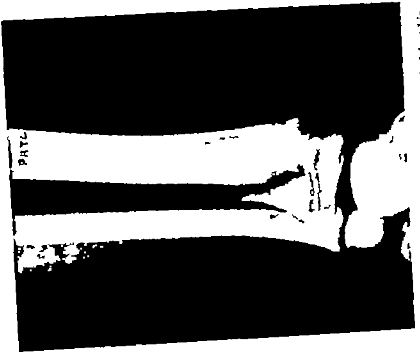


Fig 243 Fracture-separation of the lower end of the tibia.

32

Injuries of the Tarsus

Dislocation of the subtaloid joint
Dome fracture of the talus
Fracture of the body of the talus
FRACTURE OF THE NECK OF THE TALUS
FRACTURE OF THE BODY OF THE OS CALCIS
Isolated fractures of the os calcis
Other tarsal fractures

• DISLOCATION OF THE SUBTALOID JOINT

This is a rare injury It is caused by the same force as the common sprain of the subtaloid joint, and is in fact an extension of that injury A girl lands badly after vaulting a horse in the gym. or a man catches his foot in railings as he falls from a height.

The foot is inverted 90 degrees and is displaced beneath the talus, which remains in its normal position in the mortice. Extreme inversion of the foot makes the diagnosis obvious. There is severe pain and within a few hours the skin necroses over the rounded head of the talus which forms a prominence on the dorsum of the foot. Sometimes the foot is displaced laterally instead of medially

Treatment

Treatment should be prompt on account of the severity of the pain and the danger of necrosis of the skin. Under anaesthesia the foot snaps back into position. The foot should afterwards be X rayed, as there is often a fracture of the cuboid or of the anterior end of the os calcis. The patient remains in bed without splintage for a few days and exercises are started at once. As soon as he has regained muscular control of the foot he is got up without support and taught to walk without a limp The presence of fractures makes no difference, since they do not require treatment (although the doctor is held guilty of negligence if he does not get an X ray done) The patient is walking normally again within a fortnight.

• DOME FRACTURE OF THE TALUS

This is uncommon. The foot is twisted into inversion and a small fragment is sheared off the upper articular surface of the talus. The front radiograph shows

Fig. 244. Fracture of the neck of the talus. Anterior half of the talus and the foot displaced forwards. Reduction held by a plaster cast.

a small triangular fragment of bone like a loose body at the upper lateral angle of the talus. As the foot returns to its normal position the fragment may turn upside down

Treatment

If the small fragment has turned turtle it should be removed at an open operation, for it blocks movement. If the fragment is right side up no treatment is required. The patient is taught to walk without a limp as soon as he will

** FRACTURE OF THE BODY OF THE TALUS

This is rare. When a man falls from a height and lands on his heel usually the os calcis breaks and the talus remains intact; occasionally the talus bears the brunt of the force and its upper articular surface is pulped.

The ankle region is swollen and painful. The exact diagnosis is only revealed by a radiograph

Treatment

Attempts are made by active movements of the ankle to mould the comminuted articular surface so that it fits the articular surface of the tibia. As soon as the patient has regained control of the ankle he is allowed up on crutches. Weight bearing however is not permitted for three months.

Painful movement may make arthrodesis of the ankle advisable later

** FRACTURE OF THE NECK OF THE TALUS

This uncommon fracture is met with in adults as the result of forced dorsiflexion of the foot. The usual accident is an aeroplane crash The line of fracture runs vertically through the neck in a coronal plane just in front of the anterior margin of the tibia.

The displacement varies: (*a*) There may be none; (*b*) The fragment may angulate, the posterior half being in plantarflexion and the anterior in dorsiflexion (*c*) The anterior half of the talus and the foot may be shifted forwards, (*d*) The posterior half of the talus may be displaced back out of the mortice of the joint while the foot and the anterior half remain in position.

The signs are not distinctive. Swelling obscures the diagnosis, which is only revealed by a radiograph.

Treatment

Without displacement An angulation deformity is easily overlooked unless the posterior half of the subtaloid joint is studied in the lateral radiograph, if there is angular deformity at the fracture line the two articular surfaces are not parallel. Reduction is not needed if it is certain that there is not any displacement. A plaster is applied from below the knee to the toes holding the foot at a right angle. The patient is got up and taught to walk, bearing weight. After three months the plaster is removed.

Fig. 245 Fracture of the neck of the talus. Posterior half of the talus displaced back and rotated.

With angulation Reduction is obtained by forcible plantarflexion of the foot. A plaster is then applied from below the knee to the toes, ***holding the foot in equinus*** The patient remains in bed for three weeks during which the usual soft-part treatment is carried out. After three weeks the plaster is removed and the foot lies free in bed until the ankle voluntarily dorsiflexes to a right angle This movement must not be forced, it must come back of its own accord. When the ankle is at a right angle the foot is X rayed and if the angulation has not returned a new plaster is applied with the foot at a right angle. In this plaster the patient can walk, and treatment is continued as for a fracture without displacement.

With forward displacement of the foot (fig 244). The foot is forcibly plantar flexed and pushed backwards. Reduction is easy A plaster is then applied with the foot in equinus, and the treatment continued as for a fracture with angulation.

With backward displacement of the posterior half of the talus (fig 245). A Steinmann's pin is passed through the os calcis and traction applied. This opens up the space between the tibia and the os calcis, and enables the surgeon to push the posterior fragment forwards into the ankle mortice. Reduction is difficult when the posterior half of the talus is not only displaced backwards but is rotated. Closed reduction may prove impossible. If so, the ankle region is exposed from the back, when one can see exactly how the fragment is lying It is then a comparatively easy matter to restore it to its normal place in the mortice.

After reduction the foot is plastered in equinus and the usual treatment follows.

Prognosis

In spite of the plentiful blood supply to the posterior half of the talus aseptic necrosis is not uncommon particularly when the posterior half of the talus has been dislocated Some surgeons believe that the ankle should be arthrodesed immediately after reduction in this type of injury However union often occurs when the density of the talus in the radiograph suggests that aseptic necrosis is present. It seems better therefore to wait and see before deciding on an arthrodesis.

•FRACTURE OF THE BODY OF THE OS CALCIS

Fracture of the body of the os calcis is a common injury in workmen. It is important because the fracture may be overlooked and because convalescence is long It follows a fall from a height, which may not be more than a few feet; a common history is a fall from a pair of steps. Steel erectors, painters tilers and window cleaners frequently meet with this accident. The fracture is often bilateral and associated with other injuries such as a fracture of the spine.

A fracture of the os calcis should always be suspected when a man complains

Fig. 246. Fracture of the body of the os calcis. Mild displacement.

Fig. 247 Fracture of the body of the os calcis. Severe displacement.

of pain in his foot after falling and landing on his heel. The foot may appear normal, but two signs are always present. The os calcis is widened so that a finger run down the outer side of the leg passes over the tip of the lateral malleolus on to the os calcis in the same plane: in an uninjured foot the finger sinks into a marked hollow below the malleolus. The second sign concerns the subtaloid joint. A man with a fracture of the os calcis can be persuaded to move his ankle through about half its normal range but no movement can be obtained actively or passively at the subtaloid joint.

The diagnosis is confirmed by radiographs (figs. 246 247 248). The fracture lines are not easy to make out, but one or more of these may be seen. (1) A vertical sagittal fracture through the anterior part of the os calcis splitting the bone into medial and lateral halves. This fracture is only seen in the axial view (fig 249). This is a special view taken to show widening of the os calcis. (2) A vertical coronal fracture seen in the lateral view The fracture starts at the junction of the vertical and horizontal parts of the subtaloid joint (the crucial angle) and passes slightly backwards and downwards. It divides the os calcis into anterior and posterior halves. The two halves hinge and the os calcis sags in the middle. (3) A fracture more or less horizontal starting at the crucial angle and passing directly backwards. This separates off an upper posterior fragment which pivots, the anterior end being driven into the body and the back end rising (4) A portion of the articular surface of the os calcis is driven downwards into the body Often all these fracture lines are present. If occurring singly they are sufficiently definite for *split hinge see saw* and *depressed* fractures to be recognised.

Treatment

In patients over the age of 50 reduction should not be attempted. The man is kept in bed without splintage until he is moving his foot well, he is then allowed up taking weight as soon as he feels inclined.

In younger patients reduction may be attempted. Lateral compression of the heel is used for the split fracture. For the hinge fracture a horizontal spike is inserted into the os calcis from the back and used as a lever The same method is used for the see-saw fracture. For the depressed fracture the subtaloid joint is opened from the lateral side and the depressed fragment levered up After a successful reduction the foot is put into plaster for four weeks. Weight bearing is not allowed for three months from the accident. If reduction is not successful the patient is treated without splintage and early weight bearing is encouraged.

Only surgeons with a large experience of fractures of the os calcis are likely to achieve a perfect reduction and it is unwise to immobilise the subtaloid joint unless reduction is perfect. Many surgeons believe they do better by disregarding displacement and encouraging early movement. Whether early weight bearing is harmful or beneficial is sub judice; we believe it beneficial.

Fig 248 *a* (*top*) Fracture of the body of the os calcis. Severe displacement. *b* (*below*), patient standing at the end of three weeks.

Prognosis

In fractures without displacement three out of four patients should resume their former work. It is claimed that this also happens when reduction has been successful. In patients over 50 only one in two at the best will return to his former work, and at the worst one in four In any case convalescence is long and few patients are back at work under six months.

Restriction of movement at the subtaloid joint, which is sometimes great, is not as incommoding as painful movement. It is sometimes hard to trace the pain to its source Identifiable causes of pain are:

Bone projecting into the sole A large boss of bone is sometimes found projecting downwards. A painful bursa develops over it. The patient can often be made comfortable by an insole in the shoe made of sponge rubber with a hole cut in it to take pressure off the bony lump

Tarsal stiffness Limitation of movement at the other tarsal joints is to be expected if the foot has been held immobile after the injury This explains why disregarding the fracture and concentrating on rehabilitation produces better results than reduction followed by plaster

Arthritis of the subtaloid joint Incongruity of this joint is almost inevitable after a fracture of the os calcis, and some surgeons are in favour of arthrodesing the joint as soon as the immediate effects of the injury have passed away However in spite of gross irregularity of the articular surface, a small amount of painless movement sometimes returns so long as the foot has not been kept motionless in plaster

Interference with the peroneal tendons Pain under the lateral malleolus is common. This may arise in the subtaloid joint or it may be caused by interference with the peroneal tendons on the lateral aspect of the os calcis.

ISOLATED FRACTURES OF THE OS CALCIS

These are unimportant.

** FRACTURE OF THE TUBEROSITY

There are two varieties: horizontal and vertical.

The horizontal fracture is seen in a lateral radiograph as a triangular piece of bone prised up from the posterior angle of the os calcis (fig 250) Manipulation may reduce the displacement. If it does not, the fragment should be removed at open operation. The tendo achillis is not inserted into it. The patient is allowed up weight bearing as soon as the wound has healed.

The vertical fracture is only seen in the axial radiograph. The fragment is narrow and often is not displaced (fig 251) The patient is got up without splintage and made to walk.

* FRACTURE OF THE SUSTENTACULUM TALI

The fracture is often difficult to see in a radiograph. Displacement is slight and reduction is not necessary The patient is encouraged to bear weight at once.

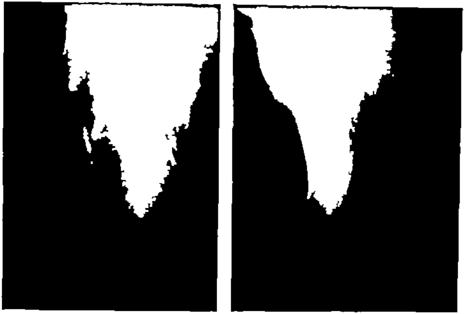


Fig 249. Axial view of a fracture of the body of the os calcis. Normal os calcis for comparison.

Fig 250 Horizontal fracture of the tuberosity of the os calcis.

• FRACTURE OF THE ANTERIOR END OF THE OS CALCIS

This fracture is associated with a severe inversion sprain of the foot or a subtaloid dislocation. A small fragment is pulled off the upper surface of the front end of the os calcis Reduction and splintage are unnecessary The patient is got up and taught to walk properly in ordinary shoes.

• FRACTURES OF THE OTHER TARSAL BONES

The navicular and the cuboid, either separately or together may be fractured in crush injuries of the foot. Often there is also a dislocation of the midtarsal joint.

Any dislocation is reduced. A plaster cast is then applied to the foot, holding it plantargrade. An overboot is fitted over the plaster and the patient is got up walking Alternatively the fracture is disregarded and the patient encouraged to walk without any support. Treatment without plaster shortens convalescence.

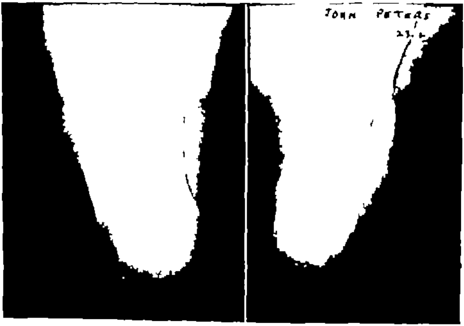


Fig 251 Vertical fracture of the tuberosity of the os calcis.

Fig. 249. Axial view of a fracture of the body of the os calcis. Normal os calcis for comparison.

Fig. 250. Horizontal fracture of the tuberosity of the os calcis.

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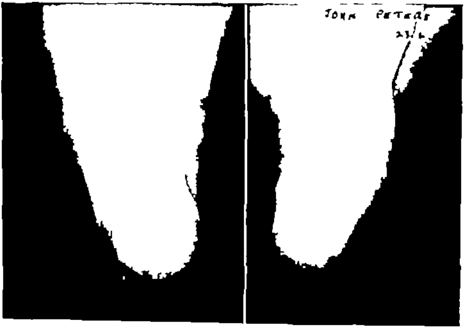

Fig. 251 Vertical fracture of the tuberosity of the os calcis.

Fig. 252. Fracture of the base of the fifth metatarsal. Compare with fig. 253.

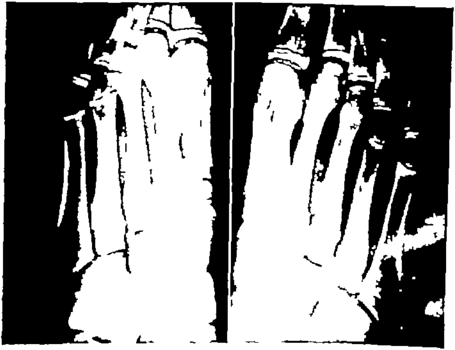

Fig. 253. Normal apophysis at the base of the fifth metatarsal.

33

Fractures of the Metatarsals and Phalanges

Fracture of the base of the fifth metatarsal
Marching fracture
Crush fracture of the metatarsals
Lateral-rotation injury of the forefoot
Fracture of the phalanges

FRACTURE OF THE BASE OF THE FIFTH METATARSAL

This is caused by excessive inversion of the front half of the foot. The antero-posterior radiograph shows a triangular piece of bone detached from the base of the metatarsal (fig 252). There is hardly any displacement. This fracture must be distinguished in the radiograph from an ununited apophysis, which has a narrow characteristic shape (fig 253).

The patient has apparently a sprain, but the tip of the lateral malleolus is not tender nor is there tenderness over the front end of the os calcis. Further examination reveals marked local tenderness on and underneath the prominence formed by the base of the fifth metatarsal.

The injury should be treated as a sprain and not as a fracture. The patient is got up and made to walk in an ordinary shoe at once. If the foot is put into plaster it remains painful for months. Treated by immediate rehabilitation the patient is walking normally in a week.

* MARCHING FRACTURE

This often occurs spontaneously without the knowledge of the patient, who reports with a painful foot. Pain may start suddenly but usually the onset is gradual and the patient denies having had an injury.

There is localised tenderness and a lump over the shaft of one of the metatarsals, usually the second. The radiograph at first only shows a fine transverse crack, indeed sometimes nothing abnormal is visible (fig 254). In ten days however the radiograph shows a mass of callus around an obvious fracture.

It is sufficient to strap the front part of the foot. Walking remains uncomfortable for several weeks.

* CRUSH FRACTURE OF THE METATARSALS

As the result of a crush or a heavy blow one or more metatarsals are broken. Usually the fractures are through the necks of the bones. Diagnosis is difficult without a radiograph. Often there is an open wound.

Recovery is better and quicker if the fracture is disregarded and the patient is treated as though he had only bruised his foot. He is got up and taught to walk as soon as he will, which is usually within a few days of the accident. The fractures are able to look after themselves, and it matters little if they join with deformity (fig 255). The important thing is to restore mobility to the toes and this is best done by avoiding immobilisation.

** LATERAL ROTATION INJURY OF THE FOREFOOT (LISFRANC'S FRACTURE DISLOCATION)

The front part of the foot is forcibly twisted. The joint between the medial cuneiform and the first metatarsal is dislocated or the base of the first metatarsal is broken. In addition, the second, third and fourth metatarsals are fractured through their necks and are displaced laterally.

Any dislocation should be reduced immediately if necessary at an open operation. Reduction is sometimes unstable and must be held by a plaster slab

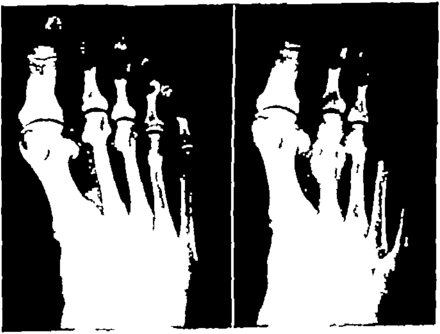

Fig 254. Marching fracture Interval six weeks.

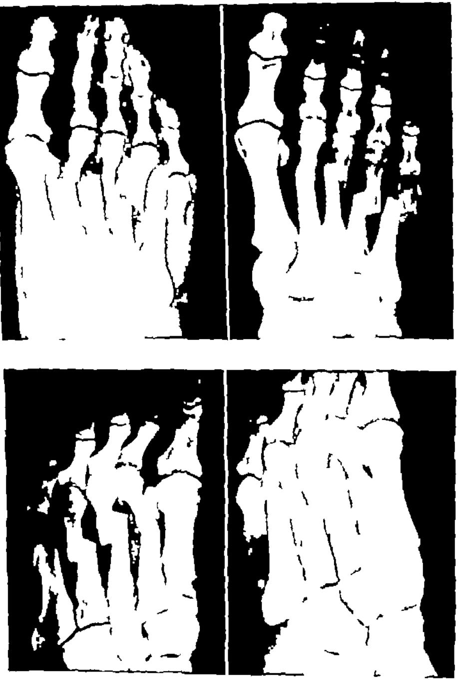

Fig. 255 *a* (*top*) Crush fracture of the metatarsals. Interval, three months. *b* (*below*) oblique view.

A complete plaster cast is best avoided so that the circulation can be better watched. Sometimes all the vessels are torn, and the foot goes gangrenous, early reduction may avoid this.

When it is certain that the circulation is satisfactory the patient is encouraged to walk without support.

• FRACTURES OF THE PHALANGES

These are unimportant. The phalanx of the big toe is often broken by a weight falling on it. The bone is fragmented. Reduction is not needed, but it is sometimes advisable to let out a pent up haematoma in order to relieve pain. The fracture does not need any treatment. As soon as the patient can get a shoe or boot on, he is able to return to work.

Index